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FERTILITY OF THE SOCIAL CLASSES IN THE NATIVE WHITE POPULATION OF COLUMBUS AND SYRACUSE[1]

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ONE of the neglected aspects of the much discussed decline in the birth rate is the problem of the incidence of the decline in constituent classes of the population. We know that the birth rate has dropped more rapidly in the foreign than in the native population. But within the native group we know little enough of the nature of the changes that have taken place. Has the decline fallen with full force on the established families which have remained unbroken? Within this group are the birth rates declining with greater rapidity in some classes than in others, and if so, are these differences tending to strengthen or weaken the well-established inverse relation between social status and fertility?

[1] From the Milbank Memorial Fund. Much of the material presented in this paper was drawn from field studies in the two cities. The Columbus study was conducted by the Department of Sociology of The Ohio State University in co-operation with the Milbank Memorial Fund. The writers wish to express their appreciation to Professor Mary Louise Mark, Professor Edith M. Miller, and Mr. William J. Blackburn, Jr., for their painstaking care in planning and supervising the field work, and to the members of their classes for securing an excellent set of records.

Part of the Syracuse data were gathered in connection with a morbidity survey conducted by the United States Public Health Service with the assistance of the Milbank Memorial Fund.

It is with a preliminary attack on some of these problems that this paper is concerned. As such it represents a continuation of the Milbank Fund's studies of differential fertility. These dealt first with the social classes of the native population as shown by special tabulations of 1900 and 1910 census data. Since later censuses have not gathered the necessary data, an attempt has been made to bring the information up to date by means of field studies in selected areas. One of these, conducted in a rural area of New York State, has been reported on elsewhere.[2] This paper continues the series by utilizing data obtained from special field studies as well as earlier census data for two selected urban communities of moderate size, Syracuse, New York, and Columbus, Ohio. Its purpose is to determine the differences in the fertility of native-born married women in the broad social classes of these communities, to compare the relative differences now with those at the beginning of the century, and to examine the trend in the fertility of specific social classes since that time.

The field work for the surveys was conducted in 1931-1932 in Columbus and in 1930-1933 in Syracuse. In the former city records were obtained from 2,941 families and in the latter from 2,890 families. Each record contained, in addition to a variety of descriptive material, the basic data relating to nativity, date and duration of marriage, age of the husband and wife, occupation of the husband and a complete birth-date roster of all children born.

The data were secured by means of virtually complete canvasses of selected areas, so that except for a small number of definite refusals, and a few persons who could not be located, a schedule was obtained from each married couple and from each person who was then or had been married but was not living with a spouse. Such complete enumeration required repeated visits and many evening calls, but the procedure was necessary to avoid missing women who worked away from home, among whom will be found a disproportionately large number of the childless. There is no reason to believe that refusal to give the information was in any way correlated with fertility and in any case the number encountered was negligible.

When sampling is done by the complete enumeration of a few selected areas, the validity of the data depends, of course, on the selection of districts in which the population is representative of the groups under consideration, and the more homogeneous these groups are the easier the selection of such districts becomes. In the present instance the task was not so complex as it at first appears. To compare the fertility of the social classes of the native population it is necessary to secure a representative sample of each class, but not one of the entire native population. Since each class by itself is a fairly homogeneous group, careful selection of the districts should yield reliable samples. Accordingly in each city persons thoroughly

[2] Sydenstricker, Edgar: A Study of the Fertility of Native White Women in a Rural Area of Western New York. The *Quarterly Bulletin* of the Milbank Memorial Fund, January, 1932, x, No. 1.

familiar with the population, selected a university community, several middle-class home-owning and home-renting sections, and a few poor and very poor areas, each as representative of its own type. The native white families enumerated in these districts when classified by the occupation of the husband should yield reliable samples of the professional, business, skilled worker, and unskilled laborer classes.

Although the samples cannot be directly tested, it is possible to examine them for the presence of certain types of bias by comparing them with reference to similar information drawn from the census tract tabulations of roughly comparable areas in each community. In Syracuse 78.6 per cent of the heads of families included in the sample were native-born, compared with 77.4 per cent in roughly comparable census tracts, and 72.0 per cent in the city. In Columbus, corresponding figures are 94.5 per cent for the survey area, 94.6 per cent for the census tracts, and 90.6 per cent for the entire city. In Syracuse there is an equally striking similarity in the distribution of households by size. This similarity suggests that the fertility of the women in the sample is about the same as that of the general run of women in the areas from which the samples were taken.[3] Similar data are not available for Columbus. About one-half of both the survey group and the tract group in Syracuse were home owners. In Columbus one-half of the survey group and 42 per cent of the tract group were home owners. In both cities the value and rentals found by the surveys were lower than those reported in the census, but this doubtless was due to the fact that most of the survey data were collected more than a year after the census enumeration and in a period of deepening depression.

Differences in the Fertility of Social Classes

Our interest now is to compare the fertility of the broad social classes in each city. Each of the classes identified, i. e., professional, business, skilled worker, and unskilled laborer, was made up from the same lists of occupations [4] as were used in the analysis of earlier census data, and each of them is limited to native white women who married only once and were living with husbands of similar nativity when enumerated, or had lived with them until they were 45 years of age.

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[3] Kiser, Clyde V.: Pitfalls in Sampling for Population Study. *Journal of the American Statistical Association,* September, 1934, xxix, No. 187, pp. 250-256.

[4] With a few minor exceptions, specific occupational groups included in the various social classes are the same as those listed in a former report: Sydenstricker, Edgar, and Notestein, Frank W.: Differential Fertility According to Social Class. *Journal of the American Statistical Association,* March, 1930, XXV, No. 169.

TABLE 1

Births per 100 Wives by Age and Social Class in Columbus and Syracuse, 1930-1933

(Native born wives of native born husbands.)

AGE OF WIFE	CHILDREN BORN PER 100 WIVES							
	Columbus 1931-32 Survey				Syracuse 1930-33 Survey			
	Professional	Business	Skilled	Unskilled	Professional	Business	Skilled	Unskilled
Total Crude Rate.....	205	219	236	357	159	191	226	317
Under 25	50	79	110	136	70	76	102	117
25-34	126	156	175	233	115	139	195	382
35-44	228	216	265	412	185	207	246	279
45-54	240	256	271	352	188	218	229	464
55-64	227	268	310	339	205	224	311	288
65 and over.....	305	304	353	463	162	353	293	462
All ages (standardized)*	176	193	224	303	149	176	215	328
Under 45 (standardized)†	148	162	195	278	130	150	194	277
	NUMBER OF WIVES							
Total	262	917	781	133	206	671	764	86
Under 25	4	47	93	11	10	50	57	18
25-34	72	198	204	15	61	204	229	17
35-44	83	274	182	17	59	187	198	19
45-54	53	192	138	23	42	108	150	11
55-64	30	137	115	31	19	72	74	8
65 and over.....	19	69	47	35	13	47	55	13
Unknown age.....	1	..	2	1	2	3	1	..

* Standardized by applying the age distributions of samples of 92,619 native born married women of all ages drawn from the 1910 census.

† Same method of standardization for age, based on age distribution of 65,070 native born married women under 45 years of age.

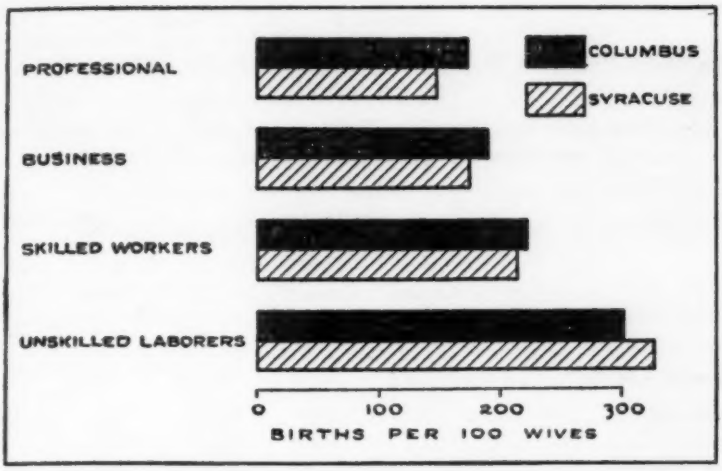

FIG. 1. STANDARDIZED BIRTH RATES BY SOCIAL CLASS AMONG NATIVE WIVES, COLUMBUS AND SYRACUSE, 1930-1933

Fertility is expressed as the total number of children ever born alive per 100 women in specified age groups at enumeration. (Table 1). The restriction of the data to the native-born and the classification by age and social status reduces the number of cases so that the resulting rates may not be interpreted closely. However, they are sufficiently reliable to give the general picture which is also given by the more stable standardized rates presented in Table 1 and Figure 1.

In each city fertility was inversely related to social status. The rates for the professional class were lowest, those for the business class next lowest, those for the skilled laborers next in order and the highest rates were found among the unskilled laborers. While the rates for the specific social classes were somewhat lower in Syracuse than in Columbus, the relative differences between the classes were much the same in each city.

In order to compare the present differences in the fertility of the social classes with those observed from earlier census data, it is necessary to restrict the newer material to women who were not only native-born but whose parents were also native-born, and whose husbands were of similar parentage. When this is done, as in Table 2, the survey material should be comparable with the census data. The coding and editing rules were the same in both cases, and except for the omission of predominately Negro and foreign wards, the census data were sys-

TABLE 2

Births per 100 Wives by Social Class in Columbus and Syracuse 1900, 1910, and 1930-33

(Rates standardized for age, footnotes Table 1, and apply to unions in which husbands and wives are native whites of native parentage.)

	COLUMBUS			SYRACUSE	
	1900 Census	1910 Census	1931-32 Survey	1910 Census	1930-33 Survey
All Ages					
All Social Classes*	...	226.9	218.0	181.7	181.4
Professional	...	174	184	156	130
Business	...	196	195	160	164
Skilled Workers	...	252	225	198	191
Unskilled Laborers	...	310	332	236	270
Under 45					
All Social Classes*	181.5	177.4	188.4	144.9	160.5
Professional	145	115	158	120	101
Business	159	148	161	129	139
Skilled Workers	198	206	195	157	181
Unskilled Laborers	248	245	325	189	223
		Number of Wives			
Total All Ages	...	3267	1423	1857	777
Professional	...	521	194	363	116
Business	...	1191	647	694	331
Skilled Workers	...	1265	508	666	292
Unskilled Laborers	...	290	74	134	38
Total Under 45	5292	2500	885	1255	509
Professional	405	388	121	240	75
Business	1958	901	392	447	212
Skilled Workers	2166	1014	342	484	197
Unskilled Laborers	763	197	30	84	25

* The rates for all women have been obtained by giving each social class the weight it bears in the Syracuse 1910 total sample adjusted to one-third the number of professional women. This adjustment compensates a corresponding greater effort made to secure a professional sample.

tematically drawn from each enumeration district, thereby insuring a representative sample of each social class.

The present differences in the fertility of the classes are more easily compared with those for 1910, and in Columbus for 1900, from the indices given in Table 3, Figure 2, than from the rates of Table 2.

TABLE 3

Comparison of 1910 Differences in Fertility of Social Classes With Those of 1930-1933

(Per cent which the standardized birth rate of each social class forms of the total rate for all classes combined in each sample—computed from Table 2.)

	COLUMBUS			SYRACUSE	
	1900 Census	1910 Census	1931-32 Survey	1910 Census	1930-33 Survey
All Ages					
Professional	...	77	84	86	72
Business	...	86	89	88	90
Skilled Workers	...	111	103	109	105
Unskilled Laborers	...	137	152	130	149
Under 45					
Professional	80	65	84	83	63
Business	88	83	85	89	87
Skilled Workers	109	116	104	108	113
Unskilled Laborers	137	138	173	130	139

The indices were obtained by expressing the standardized rates for each class as per cents of the average rate for all classes at the same time and place. In order to avoid the influence of different weights attaching to the classes in the various samples, the average rates were computed by giving each class the weight which it had in the Syracuse sample for 1910.[5]

Present differentials in fertility are much the same as those found for 1910, and in Columbus for 1900. The 1930-1933 samples, especially those for the unskilled laborer class, were small but there is a fair consistency in the order and spread of the indices for the different dates. If attention is confined to the professional, business, and skilled worker

[5] See footnote, Table 2.

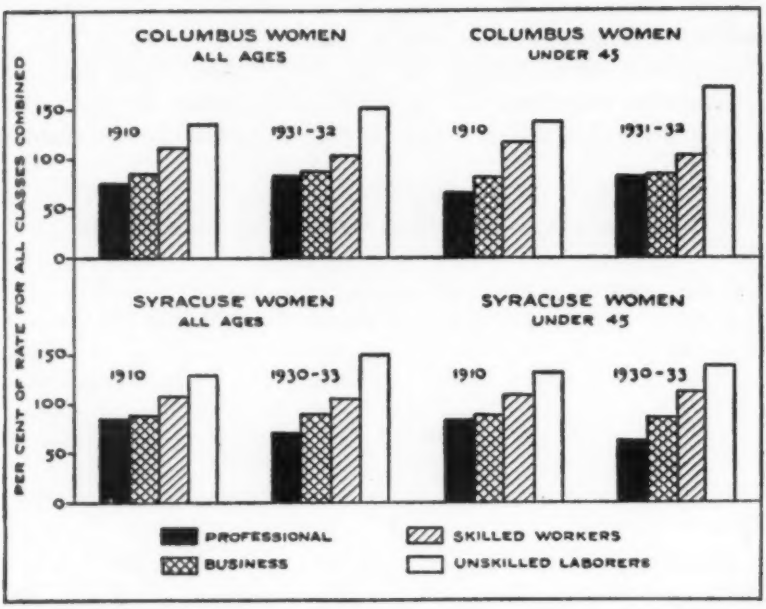

FIG. 2. RELATIVE DIFFERENCES IN THE FERTILITY OF THE SOCIAL CLASSES 1910 AND 1930-1933, COLUMBUS AND SYRACUSE

indices, which are somewhat less erratic than those for the unskilled laborers, it will be seen that the 1930-1933 differences were a little less pronounced in Columbus and a little more pronounced in Syracuse than the corresponding ones for 1910. However, the changes are too small to be of much significance, and the central fact seems to be that the relative differences in the fertility of the social classes as shown by the surveys are much the same as those found from the earlier census data.

The survey records offer an independent line of evidence for the study of changes in differential fertility. In addition to the total number of children born, they give the date of birth of each child. It is therefore possible to compute birth rates for each year of married life for women who married at different dates. These rates, when cumulated, give an index of the total number of children born prior to each marriage anniversary. Table 4 and Figure 3 present the material for marriages contracted in the periods 1890 to 1910, 1910 to 1919, and 1920 and later. Since the survey records relate only to women living in the survey period, there is a tendency for marriages that occurred a long

TABLE 4

Cumulative Birth Rates per 100 Wives in Specified Successive Years of Married Life, Social Class, and Period of Marriage

(Skeleton table from material giving rates for each successive year of married life. Data pertain to unions in which the wife was under 30 years of age at marriage and husband and wife are native-born.)

COMPLETED YEARS OF MARRIED LIFE	COLUMBUS			SYRACUSE		
	Professional	Business	Skilled Workers	Professional	Business	Skilled Workers
	Married 1920 or later					
1	16	19	29	16	24	23
3	63	74	92	70	76	85
5	104	114	134	121	127	134
7	124	140	162	141	151	176
9	158	157	183	169	177	211
11	*	173	199	*	182	219
	Married 1910-1919					
1	18	23	30	22	17	28
5	126	131	132	100	119	144
9	192	169	194	155	174	211
13	223	195	236	183	200	257
17	241	206	274	195	217	277
21	254	216	293	*	223	285
	Married 1890-1909					
1	17	22	27	13	19	20
5	129	129	133	100	120	136
9	189	193	203	149	169	207
13	223	234	246	188	205	249
17	254	260	277	207	230	282
21	258	271	292	216	239	303
25	258	276	299	218	244	307
	Number of Women at Beginning of Each Period					
Period of Marriage—						
1920 or later	81	212	257	61	215	248
1910-1919	88	270	200	64	180	196
1890-1909	76	347	253	55	173	209
	Number of Women at End of Each Period					
1920 or later	22	18	23	7	11	19
1910-1919	6	18	22	17	11	9
1890-1909	54	251	191	36	119	135

* Rate appeared to be erratic due to small numbers.

time ago to be represented in the sample by women who were young when they married. To avoid this bias, all women who married at 30 or more years of age, and all marriages contracted before 1890 have been omitted. Because of the small number of cases available, the unskilled laborer class has also been omitted from this tabulation.

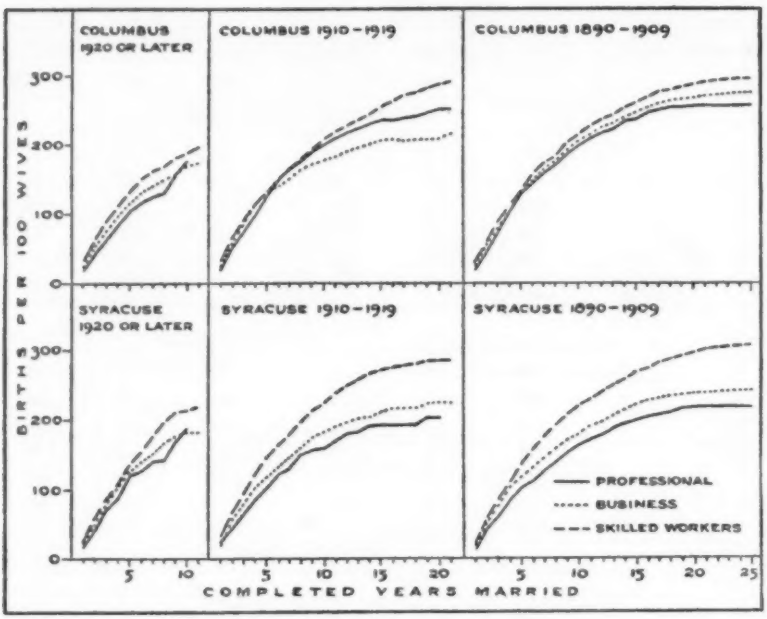

FIG. 3. COMPARISON OF THE FERTILITY OF WOMEN OF DIFFERENT SOCIAL CLASSES WHO MARRIED DURING THE SAME PERIOD

With one exception, the cumulative birth rates for each date of marriage group show the same differences in the fertility of the social classes as the total birth rates standardized for age. The exception is the Columbus group which married during the period 1910 to 1919, and arises from the fact that the birth rates for the business class of that group are low, lower even than the corresponding rates for the professional class. The data have been carefully searched for indications which would explain the matter, but nothing of consequence has been found. Pending the analysis of similar material from other areas, we

can only say that the birth rates for this part of our sample appear to be too low.[6]

In every other case, the rates for the professional class were lowest, those for the business class intermediate, and those for the skilled worker class highest. Moreover, the spread of the rates after equal numbers of years of married life was much the same for women who married in 1920 or later, from 1910 to 1919, and from 1890 to 1909. In general, therefore, the results of this analysis agree with those obtained by comparing the survey and census data in indicating that the relative differences in the fertility of the social classes have remained unchanged in these communities since 1910.

Trends in the Fertility of Native-Born Women of Specific Social Classes

If the relative differences in the fertility of the social classes under consideration have remained unchanged since 1910, the question arises whether it was because of proportional changes in the fertility of each class, or due to the absence of any change. During the same period we know that the annual birth rates declined sharply throughout the country. Much of the decline was due to the curtailment of immigration, and to an accompanying decline in the birth rate of the foreign-born. However, little is known of the changes since 1910 in the fertility of homogeneous groups of native-born women.

A downward trend in the fertility of the social classes between 1885 and 1910 is suggested by the analysis of earlier census data for northern cities, but these data are not available following 1910. Ogburn and Tibbitts'[7] comparison of the size of family in 1900 and 1930, based on samples of census data, indicates a decrease ranging from 10 per cent in the professional class to 1 per cent among unskilled laborers, but, as the authors point out, at least part of this decrease reflects changes

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[6] The suggestion that the rates for the Columbus business class, married 1910-1919, are too low instead of those for the professional class being too high is given in Figure 4. The former class is the only exception to the finding that rates for women who married during the period 1910-1919 are as high as those for women of similar social class and year of married life whose marriages took place 1890-1909.

[7] Ogburn, W. F., and Tibbitts, Clark: The Family and its Functions. *Recent Social Trends,* New York, McGraw Hill Book Company, Inc., 1933, Vol. 1, pp. 661-708.

in the composition of the family and not in fertility. Spengler,[8] analyzing the annual birth rates among the native white population, finds no evidence of declining fertility during the past fifty years in New England, but perhaps some decline in Michigan and Indiana. In each case, however, he indicates that the reliability of the data utilized is open to question.

The evidence secured from the present study is somewhat conflicting, but in general it points to the absence of decline between 1910 and the years immediately preceding the survey, in the fertility of homogeneous groups of native white married women in Syracuse and Columbus. In the near future, analyses of similar data for other cities will be possible. Pending their completion, no claim as to the further generality of the above indications will be made. The suggestion of the absence of a decline in fertility rates of native women of specific social classes is based upon: (1) the comparison of rates obtained from the survey group with those from the 1910 census samples, (2) the comparison of the fertility of women in the survey group who married at different dates, and, (3) insofar as the native population as a whole is concerned, upon available official data.

The rates for women in the survey (births per 100 wives of native parentage, standardized for age) are generally as high or higher than those for the corresponding classes in 1910, Table 2. The only 1930 rates which were substantially lower than those for 1910 were for the Syracuse professional class, and for the Columbus skilled-worker class. In Columbus the rate for all women, standardized for social class, was 227 in 1910 and 218 in 1930, and in Syracuse 182 and 181 respectively.

If there was a decline in the fertility of the population elements considered here, then either the 1930-1933 rates are too high or the 1910 rates too low. The most probable source of such difficulty, apart from that arising from the selection of the samples discussed above, would seem to lie in the under-enumeration of births at the 1910 census. The census enumerators asked for the total number of children born and the number still living. It is possible that this type of question would

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[8] Spengler, Joseph J.: The Fecundity of Native and Foreign-Born Women in New England. *The Brookings Institution Pamphlet Series*, ii, No. 1, June 30, 1930, pp. 17 and 41.

The Comparative Fertility of the Native and Foreign-Born Women in New York, Indiana and Michigan. *Quarterly Journal of Economics*, xiv, No. 3, May, 1931, pp. 475 and 483.

fail to stimulate as complete reporting of children whose death occurred soon after birth, as that used by the survey in which the date of birth of each child was required. If this situation did exist it would not be likely to invalidate the comparison of relative differences in the fertility of the social classes but would tend to mask a decline in the birth rates of specific classes.

The hypothesis that a real decline is concealed by an under-enumeration in 1910 is largely negated by internal comparison of the survey data. In Figure 4, the cumulative birth rates presented in Table 4 are plotted so that the fertility of women of the same social class who married at successive intervals since 1890 might be compared. The

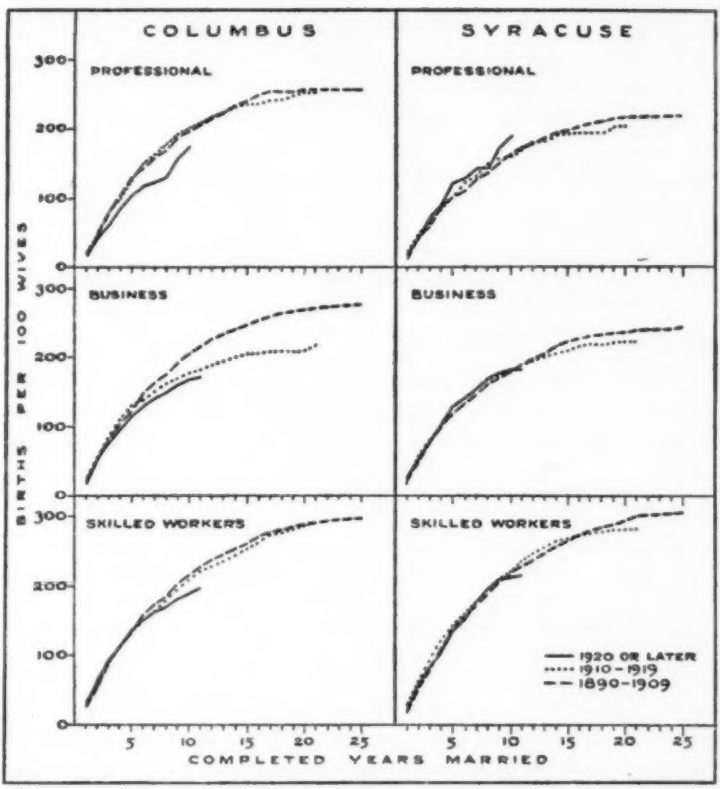

FIG. 4. COMPARISON OF THE FERTILITY OF WOMEN OF THE SAME SOCIAL CLASS WHO MARRIED DURING DIFFERENT PERIODS

married women observed in the 1910 enumeration are fairly comparable with those of the present sample who married during the period 1890-1909. It will be noted that with the exception of those for the Columbus business class, the rates for women who married between 1910 and 1919 are generally as high as those of women of identical social class and duration of marriage who married from 1890 to 1910.

TABLE 5

Births to Native White Mothers per 1000 Estimated Native White Population for Years Indicated in Columbus and Syracuse *

Year	Columbus	Syracuse
1910	17.5	...
1911	17.2	...
1912	14.8	...
1913	17.0	...
1914	...	...
1915	...	...
1916	...	17.6
1917	17.7	19.9
1918	17.3	20.6
1919	16.1	18.8
1920	17.4	19.8
1921	18.2	19.8
1922	18.1	18.6
1923	...	19.0
1924	...	18.5
1925	...	18.2
1926	...	17.8
1927	...	19.2
1928	...	19.5
1929	...	19.1
1930	...	19.1

* Except those for Columbus 1917-1922, rates are based upon births to native white mothers, from official state reports. Columbus 1917-1922 rates are based upon births of native parentage reported for these years in Federal *Birth, Stillbirth and Infant Mortality Statistics.*

Population estimates were based upon average intercensal increases.

The rates for women who married in 1920 or later, particularly in Columbus, carry the suggestion of a decline in very recent years, but they are based on a small number of cases.

It is interesting to note that the results for Columbus and Syracuse agree with those found by Sydenstricker in a rural part of Cattaraugus County, New York, where on the basis of data similar to those used in this study he concludes "that no significantly downward trend has occurred in the fertility rate of wives of farmers of native stock in this typical rural area of this section of the country." [9]

Official data are fragmentary concerning trends in the fertility of native elements of the urban population. From available information, however, there are good indications that until very recent years the fertility of these elements has remained practically unchanged since 1910. From Table 5 it will be noted that the annual birth rate of native women in Columbus remained practically the same from 1917 to 1922. Similar data for Syracuse indicate unchanging fertility from 1917 to 1930.

From census data it was possible to compute the ratios of children under 5 to white married women 15-44 years of age of all nativities in the cities studied. In Columbus, however, only 8.7 per cent of the married women 15-44 years of age were foreign-born in 1910 and only 5 per cent in 1930, so that these ratios should afford a fair indication of what has taken place among native groups in that city. For Syracuse, the ratios are less indicative of fertility trends among native-born women because the proportion of foreign-born married women of this age was 28.3 per cent in 1910 and 22.1 per cent in 1930. The following ratios were found:

	1910	1920	1930
Columbus	518.3	526.4	481.8
Syracuse	616.6	637.9	522.4

It will be noted that in both cities the fertility ratio of 1920 is even higher than that for 1910, a fact which agrees with Thompson and Whelpton's finding concerning such ratios among all urban white women of the country living in communities of 100,000-250,000 population.[10] The difference between the 1910 and 1930 ratios is much smaller in

[9] See footnote 2.

[10] Thompson, Warren S., and Whelpton, P. K.: Population Trends in the United States, McGraw-Hill Book Company, Inc., New York, 1933, p. 279.

Columbus, with its relatively small proportion of foreign-born, than in Syracuse.

In recent years there are contrary indications that the fertility of the native stock has declined, albeit little in comparison with that of the foreign-born. On the basis of number of births by age of mother from *Birth Statistics* for 1920 and 1929, Thompson and Whelpton computed a decline of 12.3 per cent in the fertility rates of native-born white women and 31.5 in that of the foreign-born in Massachusetts, Connecticut, and New York. Practically similar results were found in the North Central States.[11]

In drawing together the various lines of evidence it is fairly clear that there was no significant decline in the birth rates of native women in the two cities during the period 1910-1925. The decline after that date, small in comparison with that of the foreign-born, may easily fail to be reflected in rates which are based upon the total number of children born, and not on the annual births. This is particularly true since most of our material was collected in 1930 and 1931, and most of the children were born prior to 1925. The actual rise in the fertility of several groups as shown by the comparison of the sample with the 1910 census material may reflect somewhat the post-war rise in the birth rate and may be due to a small amount of under-enumeration of the 1910 births by virtue of the manner in which that material was gathered. The cumulative birth rates of women who married in 1920 or later, may suggest declines in recent years, but the numbers are too small for trustworthy conclusions.

The fact that the birth rates of the native population in these communities have remained relatively stationary for a considerable period lends particular interest to the differences in the fertility of the constituent classes. Ogburn appears to interpret such differences largely as the result of a lag in the diffusion of family limitation patterns from the most privileged to the least privileged classes.[12] Such a process would presumably tend to run its course and in doing so eventually to eliminate the differences between the classes. Lorimer and Osborn[13]

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[11] *Ibid.*, pp. 274-275.

[12] Ogburn, W. F.: Social Trends and the Changing Status of the American Family. Read before the American Conference on Birth Control and National Recovery, Washington, D. C., January 15, 1934.

[13] Lorimer, Frank: Discussion of the Differential Fertility of the Social Classes, *Social Forces*, October, 1933, xii, No. 1, pp. 39-42.

Lorimer, Frank, and Osborn, Fred: Dynamics of Population. New York, Macmillan Company, 1934, pp. 83, 325-326.

while accepting this view as a partial explanation, believe that the differences in fertility are also caused in part by factors of a more permanent nature. It could not be argued from the data in hand that a cultural lag has not been or is not now responsible for many of the differences in fertility observed throughout the country. However, the fact that the differences in the fertility of the classes in these communities remain clear-cut during a fairly long period of stationary birth rates lends support to the view that such differences are likely to be fairly persistent accompaniments of social class differentiations.

Summary

In summary, the population data collected recently for 2,941 families in Columbus and 2,890 families in Syracuse indicate that the inverse relation between social status and fertility among native-white married women differs little in order and degree from that of 1910. The professional class was least fertile, the rates for the business class were only slightly higher, the skilled workers were next in order and the highest birth rates were found among the unskilled laborers. The data indicate that except possibly in the last few years there has been practically no decline since 1910 in the fertility of native groups of similar social status.

BODY BUILD IN INFANTS. V. ANTHROPOMETRY IN THE NEW-BORN

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THIS report comprises measurements of the external dimensions of 1653 new-borns. Thirty-three dimensions were measured, 24 on the entire group, and 9 additional on 261 infants. The anthropometric technique used was essentially that of Hrdlička (28) and has been described in detail elsewhere (7). All measurements were made by Miss Allene Jones. Comparisons are made by sex, order of birth, social status, season of the year, and race or nationality.

Numerous measurements of weight, height, head and chest circumference in new-borns have been reported. A few other dimensions have been measured by Quetelet (40), Daffner (12), Weissenberg (49), Friedenthal (16) and Schreiber (47). The only extensive series has been recently recorded by Kugler (32).

Means, standard deviations and coefficients of variation for 33 dimensions by sex and order of birth are shown in Table 1. The external dimensions are larger in males than in females and in later born than in first born infants. The proportion of the dimensions [1] to total body length is identical in all groups of new-born.

Numerous workers have reported a change in the head form during the first days of life. The head measurements in this series of infants during the first 3 days of life showed no differences from means for the first 7 days of life and therefore all measurements are included in the calculations.

Mean weights at birth, computed by various observers, are shown chronologically in Table 2. No definite trend is apparent. It is pos-

[1] Calculations were made only for weight, bimalar diameter of face, biacromial and biiliac diameters, and circumference of chest.

TABLE 1

The External Dimensions of the New-born by Sex and Order of Birth

First Born

DIMENSION	MALES (395 cases)			FEMALES (417 cases)		
	Mean *mm.*	St. Dev. *mm.*	C. of V. *percent.*	Mean *mm.*	St. Dev. *mm.*	C. of V. *percent.*
Total body length	503.72	19.62	3.89	496.94	18.80	3.78
Body weight (*grams*)	3375.45	440.40	13.06	3222.49	517.00	16.02
Sitting height	339.99	16.63	4.89	335.15	16.31	4.87
Circumference of head	344.90	12.14	3.52	338.52	13.39	3.96
Cephalic length	117.21	4.79	4.08	114.62	4.48	3.92
Cephalic breadth	92.78	4.09	4.41	91.87	4.06	4.42
Bimalar diameter of face	70.98	4.08	5.75	70.04	4.21	6.01
Bizygomatic diameter of face	73.10	4.10	5.60	71.96	3.76	5.22
Bigonial diameter of face	56.80	3.79	6.67	56.43	3.38	6.10
Upper facial height (nasion-prosthion)	31.87	1.92	6.02	31.15	1.95	6.26
Height of lower jaw (infradentale ment.)	17.47	1.35	7.68	17.42	1.41	8.07
Height of nose	21.43	1.95	9.08	21.02	2.01	9.57
Breadth of nose	21.31	1.74	8.16	20.76	1.57	7.53
Inter-inner canthus diameter	21.50	1.89	8.81	21.00	1.75	8.33
Length of ear	35.49	2.80	7.89	34.45	2.75	7.96
Breadth of ear	24.54	1.79	7.31	24.01	1.92	7.98
Biacromial diameter	112.48	7.82	6.95	111.30	7.10	6.37
Biiliac diameter	74.22	7.74	10.42	71.87	6.63	9.23
Circumference of thorax at nipples	311.28	18.48	5.96	308.70	17.92	5.80
Length of hand	64.27	3.22	5.02	63.15	3.03	4.80
Length of palm	36.64	2.16	5.90	35.88	1.96	5.31
Breadth of palm	31.73	1.86	5.87	30.83	1.95	6.33
Length of middle finger	33.11	2.12	6.40	32.72	2.33	7.12
Length of lower extremity	218.47	10.15	4.63	216.71	10.46	4.81
	(71 cases)			(79 cases)		
Palpebral length	21.49	1.76	8.20	21.27	1.78	8.35
Length of humerus	86.23	4.67	5.42	84.46	4.46	5.29
Length of radius	71.68	3.48	4.86	70.37	3.57	5.08
Length of thigh	119.84	3.47	2.90	119.47	3.89	3.25
Length of tibia	86.85	5.07	5.83	85.34	4.89	5.75
Length of foot	78.90	3.76	4.77	77.80	3.25	4.17
Breadth of foot	30.44	1.62	5.32	29.45	1.85	6.27
Tibia-sole length *	110.10	5.49	4.98	107.86	5.24	4.86
Length of span †	503.70	16.53	3.28	501.39	18.57	3.71

* Tibia-sole length. From the lower margin of the internal condyle of the femur to the sole with the foot at right angles to the leg.

† Length of Span. The longest distance between the tips of the middle fingers with the arms completely extended, the palms facing forward.

TABLE 1—*Continued*

The External Dimensions of the New-born by Sex and Order of Birth

Later Born

DIMENSION	MALES (423 cases)			FEMALES (418 cases)		
	Mean *mm.*	St. Dev. *mm.*	C. of V. *percent.*	Mean *mm.*	St. Dev. *mm.*	C. of V. *percent.*
Total body length	508.43	20.19	3.97	502.35	19.65	3.91
Body weight (*grams*)	3539.81	517.00	14.62	3429.81	470.40	13.71
Sitting height	342.94	16.62	4.84	339.68	16.29	4.79
Circumference of head	347.61	13.55	3.90	340.68	11.69	3.43
Cephalic length	118.16	5.07	4.28	115.46	4.69	4.06
Cephalic breadth	93.71	4.30	4.59	92.46	4.22	4.57
Bimalar diameter of face	72.11	4.40	6.10	70.69	4.12	5.83
Bizygomatic diameter of face	72.86	5.53	7.58	72.93	4.07	5.58
Bigonial diameter of face	58.45	4.21	7.20	58.08	4.16	7.15
Upper facial height (nasion-prosthion)	32.21	2.23	6.94	31.38	2.09	6.63
Height of lower jaw (infradentale ment.)	17.73	1.40	7.92	17.58	1.47	8.33
Height of nose	21.72	2.09	9.63	21.09	2.00	9.50
Breadth of nose	21.68	1.78	8.21	21.05	1.67	7.93
Inter-inner canthus diameter	21.92	1.74	7.96	21.33	1.72	8.08
Length of ear	35.55	2.91	8.18	34.88	2.69	7.70
Breadth of ear	24.82	2.00	8.06	24.21	1.72	7.12
Biacromial diameter	114.93	7.45	6.51	113.81	7.36	6.47
Biiliac diameter	76.79	7.11	9.26	73.61	7.40	10.10
Circumference of thorax at nipples	318.60	19.11	5.98	314.63	18.51	5.88
Length of hand	65.01	3.34	5.14	63.82	3.52	5.52
Length of palm	37.12	2.15	5.78	36.26	2.13	5.81
Breadth of palm	32.17	1.89	5.88	31.20	1.60	5.13
Length of middle finger	33.71	2.40	7.12	32.96	2.40	7.27
Length of lower extremity	220.12	10.46	4.75	218.39	10.72	4.91
	(62 cases)			(49 cases)		
Palpebral length	21.60	2.06	9.54	21.89	1.90	8.67
Length of humerus	86.69	6.48	7.47	85.09	6.39	7.50
Length of radius	73.19	4.57	6.25	73.01	4.03	5.52
Length of thigh	119.68	4.23	3.54	120.91	4.30	3.56
Length of tibia	87.94	6.19	7.05	87.50	6.30	7.20
Length of foot	80.07	4.18	5.22	79.93	3.88	4.86
Breadth of foot	31.11	2.19	7.04	30.26	2.21	7.30
Tibia-sole length	110.60	6.58	5.96	111.48	5.93	5.32
Length of span	505.43	20.78	4.11	505.17	22.94	4.54

TABLE 2

Mean Weight at Birth (1753-1931)

AUTHOR	YEAR	CITY OR COUNTRY	MEAN WEIGHT AT BIRTH—*grams*	
			Males	Females
Roederer .....(45)	1753	Göttingen	2990	2854
Clarke .....(11)	1785	London	3343	3058
Siebold .....(48)	1832-1858	Göttingen	3221	3079
Hecker .....(23)	1861	Munich	3310	3230
Haacke .....(21)	1862	Leipzig	2945	2854
Winckel .....(51)	1862	Berlin	3057	2940
Quetelet .....(40)	1870	Brussels	3100	3000
Gregory .....(18)	1871	Munich	3386	3331
Kézmársky .....(31)	1873	Budapest	3383	3284
Altherr .....(3)	1874	Germany	3214	3077
Bowditch .....(9)	1877	New England	3424	3280
Fasbender .....(13)	1878	Stuttgart	3347	3250
Peterson .....(38)	1882	Sweden	3595	3455
Issmer .....(30)	1872-1883	Dresden	3320	3214
Mies .....(33)	1891	Cologne	3375	3301
Schäffer .....(46)	1896	Munich and Heidelberg	3258	3011
Recht .....(41)	1897	Bonn	3607	3149
Gundling .....(20)	1898	Erlangen	3268	3148
Pearson .....(36)	1899	London	3311	3209
Herz .....(26)	1900	Freiburg i. B.	3274	3113
Fourman .....(14)	1901	South German	3360	3221
Daffner .....(12)	1902	Leipzig	3335	3278
Fuhrmann .....(17)	1906	St. Petersburg	3490	3185
Heiberg .....(24)	1907	Denmark	3487	3280
Griffith and Gittings.(19)	1907	Philadelphia	3494	3418
Holt .....(27)	1911	New York	3400	3260
Schreiber .....(47)	1927	Göttingen	3552	3372
Kugler .....(32)	1931	Zurich	3420	3310
Authors .....(..)	1930-1931	New York	3459	3326
Miwa .....(34)	1901	Japan	2940	2780
Nagahama .....(35)	....	Japan	2900-3000	2770-2800
Authors .....(5)	1930-1931	Negro—New York ..	3100	2916
Authors .....(..)	1930-1931	Porto Rican—N. Y....	3191	3109

sible, however, that a trend is obscured due to reduction in the size of families during recent years, thereby changing the distribution of first and later born children in the groups.

The mean birth weights, computed by various observers, differ fairly widely (Table 2). Though race may account for differences between white and colored infants, it seems hardly likely that it explains the rather striking differences between English and Danish, or English and American (New England, 1877) new-borns; or, for that matter, between new-borns from various sections of the same country.

Birth weight increases up to the sixth pregnancy after which it declines (29) (32). Age of the mother bears no relation to the birth weight (29) except in so far as older mothers have later born, hence heavier, new-borns more often than young mothers.

SOCIAL STATUS

According to Peller (37) and to Kugler (32) illegitimate infants weigh less and are shorter than legitimate infants. They attribute this to the unfavorable environment of the unmarried mothers. The possibility that the lower birth weight may be due to the high proportion of first borns among illegitimate infants was not considered.

Retourner (43) and Frey (15) found that infants born of unemployed mothers (house-wives) are heavier than infants born of mothers who are employed away from home up to the time of delivery. According to Pinard (39) and Bachimot (4) the children of women who had lived in the hospital 3 months prior to delivery averaged 500 grams heavier than those of patients who had entered the hospital just before or during labor. They attributed this difference to the improved hospital fare and to the absence of premature labor incident to hard work.

Williams (50) believes that social status exerts a marked influence on the new-born's weight. Thus the mean birth weight of healthy full-term infants in his private practice, which was almost exclusively among the well-to-do classes, was 3795 grams as compared with 3317 grams for the white infants in hospital practice.

In Table 3 various dimensions are compared in two groups of male new-borns from different social environments by order of birth. Infants born in the Fifth Avenue Hospital come, for the most part, from homes of moderate income, the parents being able to pay about $75.00 for the expenses of delivery, hospitalization, etc. Infants born in Bellevue Hospital come almost exclusively from very poor homes, the deliveries being free excepting in rare instances. Less than 10 per cent of the

TABLE 3

Comparison of Various External Dimensions in New-borns From Different Social Environments

Males—First Born

DIMENSIONS	FIFTH AVENUE HOSPITAL (114 cases) Mean	St. Dev.	C. of V.	BELLEVUE HOSPITAL (205 cases) Mean	St. Dev.	C. of V.
	mm.	*mm.*	*per cent*	*mm.*	*mm.*	*per cent*
Total body length	508.86	17.72	3.48	500.28	21.03	4.17
Body weight (*grams*)	3432.00	453.40	13.22	3331.00	430.40	12.94
Bimalar diameter of face	71.44	3.90	5.46	70.78	3.93	5.55
Circumference of thorax at nipples	316.73	18.29	5.77	308.08	17.44	5.68
Biacromial diameter	114.34	7.64	6.67	112.05	7.79	6.95
Biiliac diameter	75.88	7.11	9.35	74.17	7.46	10.80
	Later Born					
	(91 cases)			(265 cases)		
Total body length	514.92	20.87	4.06	506.84	20.55	4.03
Body weight (*grams*)	3588.00	471.20	13.12	3536.00	516.60	14.60
Bimalar diameter of face	72.65	5.47	7.52	72.29	4.09	5.65
Circumference of thorax at nipples	322.09	19.95	6.22	317.75	18.44	5.80
Biacromial diameter	116.71	7.94	6.79	115.37	7.30	6.33
Biiliac diameter	78.56	7.23	9.21	76.98	6.55	8.63

infants at Bellevue Hospital are born out of wedlock.[2] Almost all mothers in both groups are housewives, very few being employed away from home during pregnancy.

Infants born in the Fifth Avenue Hospital are regularly larger in all dimensions studied than are the Bellevue Hospital new-borns. The differences are greater for first than for later born infants. In most instances the differences are statistically reliable. The proportions of the dimensions to total body length are identical in both groups.[3]

[2] The U. S. A. birth certificate does not require information regarding marriage of the parents and "legitimacy" of the child can often only be guessed at. It is interesting to note that, in the social group studied, mothers of infants born out of wedlock impressed social workers as in better than average physical condition.

[3] Calculations were made only for weight, bimalar diameter of the face, biacromial and biiliac diameters, and circumference of the chest.

SEASONAL VARIATION

Adersen (2) noted a seasonal variation in the birth weight, the new-borns being larger during the cold weather. Hansen (22) found that new-borns were heavier during the fall than during the spring months. According to Abels (1) new-borns in Vienna, during the years following the war, weighed more during the summer than during the winter. Brenton (10), and more recently Hellmuth (25), however, have been unable to find any seasonal variation in birth weight. Bakwin and Bakwin (6) found no constant seasonal fluctuation in the birth weight.

Means and standard deviations were calculated for the first 24 dimensions shown in Table 4 by 3-monthly periods. A seasonal variation was found in the following dimensions: bimalar diameter of face, upper facial height, height of lower jaw, nasal height and breadth, biacromial diameter, biiliac diameter, circumference of thorax and the hand dimensions. These dimensions were smallest during the spring and summer and largest during the autumn and winter.

TABLE 4

The Influence of Season of the Year on the External Dimensions of the New-born

DIMENSION	MEAN AND PROBABLE ERROR OF MEAN (*millimeters*)			
	February March April (194 cases)	May June July (238 cases)	August September October (572 cases)	November December January (213 cases)
Total body length	491.50± 1.069	498.32± 0.950	496.96± 0.574	494.98± 1.456
Body weight (*grams*)	3284.02±23.82	3371.85±23.34	3307.52±12.75	3331.92±23.07
Bimalar diameter of face	71.59± 0.167	71.10± 0.200	69.54± 0.123	73.15± 0.160
Upper facial height	30.82± 0.092	30.01± 0.099	30.40± 0.047	31.44± 0.071
Height of lower jaw	16.75± 0.080	16.60± 0.062	17.19± 0.039	17.47± 0.056
Height of nose	20.62± 0.068	19.87± 0.077	19.58± 0.040	21.08± 0.061
Breadth of nose	21.04± 0.066	20.13± 0.070	19.60± 0.044	21.30± 0.058
Biacromial diameter	112.94± 0.352	110.60± 0.311	109.35± 0.199	114.66± 0.272
Biiliac diameter	78.82± 0.181	75.08± 0.236	67.71± 0.190	80.44± 0.220
Circumference of thorax	315.62± 0.805	308.66± 0.863	300.14± 0.497	320.42± 0.781
Length of palm	36.12± 0.098	35.00± 0.098	35.46± 0.052	36.11± 0.086
Breadth of palm	30.98± 0.081	30.54± 0.088	30.11± 0.051	31.85± 0.082
Length of middle finger	32.98± 0.082	32.11± 0.092	31.20± 0.063	34.38± 0.088

RACE OR NATIONALITY

Race is generally believed to be a factor influencing the size of the new-born.

Miwa (34) and Nagahama (35) found Japanese new-borns to weigh less than 3000 grams. According to Riggs (44) the mean birth weight of Negro infants in Baltimore is 3104.8 grams in comparison with 3316.9 for whites. A similar striking difference has been noted for Negroes in New York City (Table 2). Porto Rican new-borns are also lighter than Whites (males, 149 cases, mean 3191 grams, standard deviation 415.0 grams; females, 209 cases, mean 3109 grams, standard deviation 402.5 grams).

Means and standard deviations were calculated for the first 24 dimensions in Table 5 by nationality of the parents. The same criteria for estimating nationality were used as in a previous study (8). Some of the calculations are shown in Table 5. No significant differences were found in any of the dimensions.

TABLE 5

The Influence of Nationality of the Parents on the External Dimensions of the New-Born

DIMENSION	MEAN AND PROBABLE ERROR OF MEAN (*millimeters*)			
	North European (234 cases)	Central European (103 cases)	Mediter-ranean (194 cases)	Jewish (73 cases)
Total body length	499.57± 0.91	496.51± 1.32	494.95± 0.99	498.36± 1.64
Body weight (*grams*).....	3365.81±23.1	3356.31±30.5	3284.54±22.6	3382.19±43.4
Bimalar diameter of face..	71.14± 0.19	71.10± 0.25	70.60± 0.19	71.25± 0.30
Height of lower jaw.....	17.12± 0.06	17.10± 0.09	17.26± 0.08	16.96± 0.14
Height of nose.....	20.07± 0.07	20.17± 0.10	20.40± 0.09	20.56± 0.12
Biacromial diameter	111.38± 0.34	112.50± 0.47	111.71± 0.32	112.22± 0.59
Biiliac diameter	74.22± 0.34	74.38± 0.49	73.74± 0.38	74.96± 0.56
Circumference of thorax..	310.21± 0.83	309.90± 1.19	309.38± 0.87	313.70± 1.48

DISTRIBUTION

The distribution of weights of first born males and females is skewed positively (Chart 1). Later born infants show an approximately normal distribution.

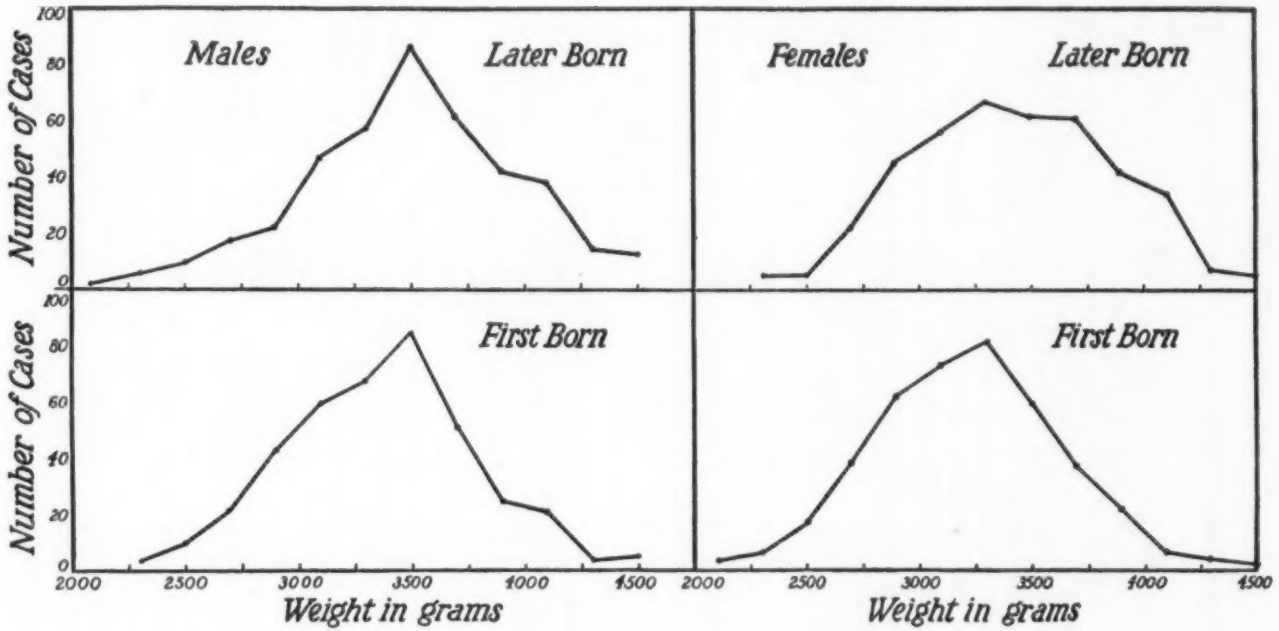

CHART 1. FREQUENCY DISTRIBUTIONS OF WEIGHTS OF NEW-BORN INFANTS

TABLE 6

The Correlation Coefficients of Various External Dimensions in 608 Male New-borns

TABLE 6

The Correlation Coefficients of Various External Dimensions in 608 Male New-borns

	SITTING HEIGHT	BIMALAR DIAMETER OF FACE	UPPER FACIAL HEIGHT	HEIGHT OF LOWER JAW	HEIGHT OF NOSE	BREADTH OF NOSE	INTER-INNER CANTHUS	LENGTH OF EAR	BREADTH OF EAR	BIACROMIAL DIAMETER	BIILIAC DIAMETER	CIRCUMFERENCE OF THORAX AT NIPPLES	LENGTH OF PALM	BREADTH OF PALM	LENGTH OF MIDDLE FINGER	LENGTH OF LOWER EXTREMITY	WEIGHT
Total body length	.686	.340	.315	.268	.161	.210	.276	.220	.233	.463	.247	.490	.477	.359	.316	.612	.661
Sitting height	...	.353	.276	.244	.138	.242	.324	.204	.247	.447	.223	.459	.468	.334	.270	.570	.704
Bimalar diameter of face	...	...	.317	.338	.320	.482	.456	.367	.379	.598	.595	.650	.409	.536	.566	.416	.582
Upper facial height (nasion-prosthion)	...	...	...	.357	.540	.349	.250	.361	.362	.437	.302	.396	.431	.390	.398	.367	.379
Height of lower jaw (infradentale ment.)	...	...	...	...	.245	.261	.236	.272	.276	.368	.194	.367	.246	.305	.298	.356	.364
Height of nose	...	...	...	...	...	.492	.304	.322	.337	.391	.420	.423	.359	.435	.518	.287	.233
Breadth of nose	...	...	...	...	...	...	.379	.321	.368	.548	.526	.561	.352	.500	.543	.282	.360
Inter-inner canthus diameter	...	...	...	...	...	...	...	.209	.267	.393	.318	.396	.273	.376	.358	.348	.433
Length of ear	...	...	...	...	...	...	...	...	.505	.436	.362	.414	.352	.353	.429	.265	.298
Breadth of ear	...	...	...	...	...	...	...	...	...	.365	.296	.400	.340	.383	.413	.281	.301
Biacromial diameter	...	...	...	...	...	...	...	...	...	...	.595	.722	.459	.576	.575	.524	.587
Biiliac diameter	...	...	...	...	...	...	...	...	...	...	...	.729	.360	.529	.666	.361	.414
Circumference of thorax at the nipples	...	...	...	...	...	...	...	...	...	...	...	...	.494	.614	.653	.556	.685
Length of palm	...	...	...	...	...	...	...	...	...	...	...	...	...	.481	.506	.491	.526
Breadth of palm	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.596	.453	.492
Length of middle finger	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.452	.434
Length of lower extremity	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.599

TABLE 7

The Correlation Coefficients of Various External Dimensions in 609 Female New-borns

	SITTING HEIGHT	BIMALAR DIAMETER OF FACE	UPPER FACIAL HEIGHT	HEIGHT OF LOWER JAW	HEIGHT OF NOSE	BREADTH OF NOSE	INTER-INNER CANTHUS	LENGTH OF EAR	BREADTH OF EAR	BIACROMIAL DIAMETER	BIILIAC DIAMETER	CIRCUMFERENCE OF THORAX AT NIPPLES	LENGTH OF PALM	BREADTH OF PALM	LENGTH OF MIDDLE FINGER	LENGTH OF LOWER EXTREMITY	WEIGHT
Total body length	.775	.437	.279	.315	.185	.276	.397	.410	.331	.562	.289	.600	.502	.478	.367	.689	.718
Sitting height	...	.381	.217	.275	.165	.229	.355	.366	.279	.480	.248	.498	.440	.437	.285	.575	.685
Bimalar diameter of face	...	...	.272	.288	.272	.466	.469	.402	.295	.504	.569	.614	.364	.491	.489	.383	.527
Upper facial height (nasion-prosthion)	...	...	...	.265	.543	.355	.260	.331	.310	.334	.256	.359	.314	.336	.339	.272	.313
Height of lower jaw (infradentale ment.)	...	...	...	...	.188	.197	.281	.200	.210	.221	.112	.283	.228	.263	.242	.280	.311
Height of nose	...	...	...	...	...	.454	.248	.272	.310	.311	.443	.441	.311	.317	.468	.279	.218
Breadth of nose	...	...	...	...	...	...	.379	.334	.377	.442	.540	.544	.317	.470	.488	.257	.360
Inter-inner canthus diameter	...	...	...	...	...	...	...	.269	.246	.363	.299	.424	.378	.346	.327	.344	.426
Length of ear	...	...	...	...	...	...	...	...	.474	.432	.394	.485	.365	.377	.395	.366	.339
Breadth of ear	...	...	...	...	...	...	...	...	...	.424	.310	.422	.333	.365	.328	.316	.318
Biacromial diameter	...	...	...	...	...	...	...	...	...	...	.518	.687	.468	.574	.507	.440	.551
Biiliac diameter	...	...	...	...	...	...	...	...	...	...	...	.657	.293	.509	.641	.308	.328
Circumference of thorax at the nipples	...	...	...	...	...	...	...	...	...	...	...	...	.500	.651	.620	.562	.682
Length of palm	...	...	...	...	...	...	...	...	...	...	...	...	...	.472	.421	.487	.532
Breadth of palm	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.547	.442	.565
Length of middle finger	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.398	.375
Length of lower extremity	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.575

VARIABILITY

There is no striking difference in variability of the dimensions between boys and girls. Of the first born infants, males are more variable, i.e. coefficient of variability is greater in 16 dimensions and the females in 17 dimensions. Of the later born infants, males are more variable in 20 dimensions, females in 12, and in one the variabilities are identical. The least variable of the dimensions measured was the length of thigh.

CORRELATION

In Tables 6 and 7, correlation coefficients for 24 dimensions are shown separately by sex. The correlation between total body length and weight at birth is higher than in later life as shown by Pearson (36) (Table 8).

TABLE 8

Height-Weight Correlations

AUTHOR	AGE	SEX	CORRELATION COEFFICIENT AND PROBABLE ERROR
Pearson .....(36)	New born	Male	0.644 ±0.012
	New born	Female	0.622 ±0.013
Authors	New born	Male	0.661 ±0.0154
	New born	Female	0.718 ±0.0142
Pearson .....(36)	Adults	Male	0.486 ±0.016
	Adults	Female	0.721 ±0.026
Reed and Love (42)	21-25 years	Male	0.5536±0.0096
	26-35 years	Male	0.4558±0.0094
	36-45 years	Male	0.4429±0.0095
	46-55 years	Male	0.4280±0.0121
	56-64 years	Male	0.4059±0.0212

SUMMARY

1. Tables are presented showing the means and standard deviations for 33 dimensions in the new-born by sex and parity (white infants only).

2. New-borns from a poverty-stricken environment were smaller in all dimensions than new-borns from a more favorable environment. The proportions of the various dimensions to total body length were identical in both groups.

3. Nationality of parents has no influence on the size of the dimensions.

4. Season of the year has no influence on weight and height. A seasonal variation was noted in the size of various dimensions, however, these being smaller during the spring and summer and larger during the autumn and winter.

5. The weight distribution of first born males and first born females is skewed positively. The weight of later born infants shows a normal distribution.

6. Correlation coefficients for 24 dimensions are given.

For permission to make measurements on the new-borns, thanks are due to Doctor Frederick Rice of Bellevue Hospital, Doctor Leon S. Loizeaux of the Fifth Avenue Hospital, Doctor Hervey C. Williamson of the New York Nursery and Child's Hospital, and Doctor Caroline S. Finley of the New York Infirmary for Women and Children.

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INHERITED REDUCTIONS IN THE DENTITION OF MAN

BY ADOLPH H. SCHULTZ

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TWO years ago the author published a brief report on the hereditary reduction and elimination of the upper lateral incisors of man.[1] By means of a few pedigrees it was shown that the tendency to suppress these teeth can be inherited in quite different manners in different cases.

It is a well-established fact that the evolutionary trend toward reduction in the number of teeth in the permanent dentition of man affects the dental row not indiscriminately at any place, but in the vast majority of the cases only at its opposite ends, namely the last molars and the incisors. Among the latter only the lateral incisors of the upper jaw and only the medial ones of the lower jaw appear to be subjected to this process of gradual elimination. As has been pointed out in the author's former paper on this subject, congenital lack of these incisors and of the last molars is not restricted to man, but occurs in some other primates as well. In a recent survey of the dentitions of nearly two thousand skulls of adult monkeys and apes the author[2] found the congenital lack of third molars on a general average in 1.4 per cent of the cases (e.g., *Ateles* = 7.6 per cent[3]; *Cebus* = 4.8 per cent; *Hylobates* = 3.8 per cent), the lack of upper lateral incisors in 0.1 per cent

[1] The hereditary tendency to eliminate the upper lateral incisors. HUMAN BIOLOGY, 4: 34-40, 1932.

[2] Eruption and decay of the permanent teeth in primates. Manuscript, as yet unpublished; 1934.

[3] It is significant in this connection that third molars were found to be congenitally absent in the species *Ateles geoffroyi* in 15.4 per cent of the specimens from Eastern Nicaragua, but in only 3.5 per cent of the specimens from Chiriqui, Panama.

(only in one gorilla [4] and in one gibbon), and the congenital absence of lower medial incisors in 0.8 per cent (e.g., *Alouatta* = 3.8 per cent; *Nasalis* = 2.4 per cent; *Pan* = 1.7 per cent; *Gorilla* = 1.4 per cent). In the modern races of man the third molars are absent or markedly reduced in sometimes 10 and more per cent of the cases in the series examined. The congenital lack of the upper lateral incisors of man is very much rarer, though (in contrast to this relation in other primates) much more common than the lack of the lower medial incisors.

As far as the author could ascertain, no case has been recorded before in which manifestations of reductions in the third molars *and* in the incisors occurred simultaneously in the same individual, nor has the writer ever encountered this combination of the two localized trends in any monkey or ape. That one and the same dentition can be reduced at its anterior as well as its posterior end is shown by the case pictured in figure 1. This is the skull of an American of Bohemian parentage,

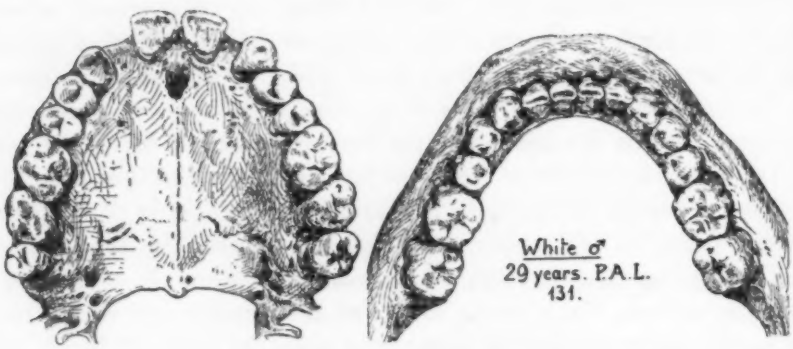

FIG. 1. UPPER AND LOWER JAW OF MALE WHITE SHOWING CONGENITAL LACK OF UPPER LATERAL INCISORS AND OF LOWER THIRD MOLARS

29 years of age, with a remarkably well preserved set of permanent teeth (Collection of Labor. of Phys. Anthropol., Johns Hopkins Univ.). In the upper jaw both lateral incisors, and in the lower jaw both third molars are congenitally lacking and the upper right third molar is considerably reduced in size.

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[4] Regnault, F. (1893, Des malformations dentaires chez le singe. *Comp. rend. de la soc. de biologie, Paris,* 931-934) mentions a gorilla in which both upper lateral incisors are strikingly reduced and the writer (in paper named in footnote 1) has recorded the case of another gorilla, showing the same condition.

The absence of third molars together with at least a striking reduction in size of one of the upper lateral incisors occurs in several members of the family whose pedigree is shown in figure 2. The writer is

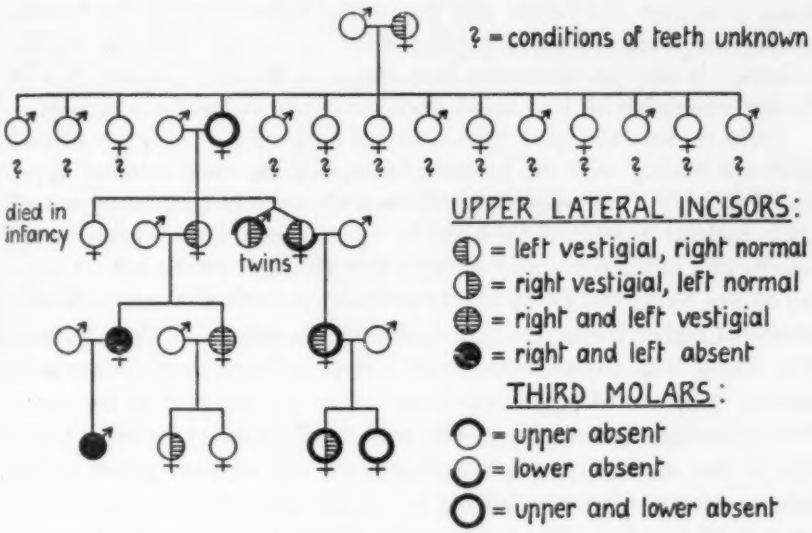

FIG. 2. PEDIGREE DEMONSTRATING THE INHERITED TENDENCY TO ELIMINATE UPPER LATERAL INCISORS AND THIRD MOLARS

greatly indebted to Mr. Huntington Cairns for all the detailed and reliable information upon which this pedigree is based. This family is composed of American whites, the mother in the first generation of the pedigree is also of American parentage. The lack of the last permanent molars is recorded in four successive generations and may, or may not, be associated with a degeneration of the right or the left upper lateral incisor.

As in the case of all previously published pedigrees (see Schultz, 1932), the one in figure 2 shows that it is not a particular variation among the many possible, different degrees of reduction of the upper lateral incisors which is inherited, but rather the general tendency toward the elimination of these teeth. This tendency is evident in the individuals of the present pedigree in various degrees. In some cases only one of the two teeth is strikingly reduced in width and in height, and hence is not meeting its antagonist in the lower jaw, in another case

both lateral incisors are vestigial, and in two further cases these teeth are completely lacking and, incidentally, known not to be merely embedded in the jaw. In the male with complete lack of the two incisors there is on each side a diastema of smaller size than in the skull in figure 1 between the canine and the medial incisor, but in the female, lacking the same teeth, the canines stand in contact with the medial incisors. It may be mentioned here that it is definitely known that in the last generation all four upper deciduous incisors had been present.

Quite recently Campbell [5] has reviewed some of the (mostly medical) literature dealing with or, in his opinion, bearing upon missing upper lateral incisors. He reports that these teeth were lacking in 35 out of 2,000 patients examined by him; in 15 instances both incisors were missing and in the remaining 20 cases only the right or the left. Campbell quotes Sichel and Lintz who have found the lack of these teeth with somewhat higher frequency. By combining the data of all three authors it is found that one or both upper lateral incisors were congenitally missing in 97 out of 3,550 individuals, or in 2.7 per cent of the cases. This percentage agrees quite closely with the findings of Hrdlička [6] who reports that among 1,000 white Americans one or both upper lateral incisors were congenitally lacking in 1.4 per cent of males and in 3.0 per cent of females. The percentage obtained from Campbell's data is furthermore in strikingly close agreement with the results of a study by Cohen and Anderson [7] who found the congenital absence of upper lateral incisors in 2.5 per cent of 1,466 school children over ten years old of Minneapolis.

Campbell mentions some new instances of the repeated occurrence of the congenital absence of these teeth among relatives and discusses the known or suspected presence of syphilis in the same families. This part of his paper he summarizes as follows: ". . . it is seen that the anomaly of missing lateral incisors shows no evident special laws of inheritance; it passes on from father or mother irrespectively, to son or daughter equally irrespectively, and to grandsons and granddaugh-

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[5] Campbell, D. K. 1934. Congenitally missing upper lateral incisor teeth. *Dental Cosmos*, 76: 459-471.

[6] Hrdlička, A. 1921. Further studies of tooth morphology. *Amer. J. of Phys. Anthropol.*, 4: 141-176.

[7] Cohen, J. T. and J. E. Anderson. 1931. Note on the eruption of the permanent teeth in a group of subnormal children, including an observation on the frequency of congenitally missing laterals. *J. Genetic Psychology*, 39: 279-284.

ters. Similarly, it occurs in the children of individuals with Hutchinson's incisors and in congenital syphilitics." Unfortunately Campbell was evidently misled by the mere coincidence of the occasional joint occurrence of missing incisors and of a history of syphilis since he draws the following unjustified and in its last part absurd conclusion: "While I should not want it understood that I consider every individual with missing lateral incisors necessarily a second or third generation syphilitic, I do believe, in the light of the evidence, that it is difficult to exclude the possibility of an original syphilitic injury to the incisor region. This injury may ultimately become a dominant inheritable character and be handed down for numerous generations."

The last sentence of Campbell's paper: "I believe that missing lateral incisors, equally with Hutchinson's teeth, are of value as a delicate but precious clinical diagnostic sign" might be corrected to read: I believe that the hereditary tendency to eliminate the upper lateral incisors is of value as a precious sign of a normal evolutionary trend.

POLYISOMERISM AND ANTHROPOGENY*

BY WILLIAM K. GREGORY

IN THIS Section of Anthropology it may seem somewhat inappropriate that the title of the present paper should be Polyisomerism and Anthropogeny instead of Anthropogeny and Polyisomerism. The reason is that polyisomerism is an aspect of the evolutionary process which has applications in several fields besides that of anthropogeny.

But what is polyisomerism and, for that matter, what is anthropogeny? In the works of Ernst Haeckel, anthropogeny, the story of evolution from *Monera* to man, sprang largely from his interpretations and application of the doctrine that ontogeny recapitulates phylogeny. Consequently many of the supposed stages of ascent which Haeckel named were hypothetical reconstructions from embryological data. In what I have ventured to call the "New Anthropogeny,"[1] however, all the elaborate deductions from embryology are set aside or held in abeyance, and the story of man's evolution has been pieced together anew from the broken bits that have been saved in the palaeontological record, aided by a new critique of the data of comparative anatomy, comparative physiology and the taxonomy of the vertebrates. In the address to which I refer it was pointed out that the new anthropogeny is not the product of any one man but has grown up almost without conscious effort, since it has emerged from the discovery of numerous fossil vertebrates, unknown or little appreciated in Haeckel's time, which are now seen to be of great significance in anthropogeny.

On the same occasion I showed illustrations of an exhibit entitled "The Skeleton from Fish to Man" in the new Hall of the Natural History of Man in the American Museum of Natural History; but I was careful to point out that it was not claimed that this is a series of direct ancestors and descendants but that it is the nearest to a direct line so far

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* Read before Section H (Anthropology) of the American Association for the Advancement of Science, December 28, 1933.

[1] *Science*, Vol. 77, No. 1985, Jan. 1933, pp. 29-40.

discovered. I may have failed, however, to stress the fact that this series represents the very small residuum after the elimination of the thousands of other forms of vertebrates which, by acquiring definite skeletal specializations of numerous sorts, have thereby removed themselves still further away from the line of ascent to man.

The modern classification of the classes, orders, families and genera of fossil and recent vertebrates has long ago outgrown the stage where any reliance is placed by palaeontologists upon single characters as a basis of classification. Hence modern taxonomy has constantly tended to express more and more closely not mere artificial groupings but the real branches of the tree of life, as they gradually separated from each other in space and time. This is why I maintain that the new anthropogeny is a part of the science of vertebrate taxonomy, which rests upon an analysis chiefly of the skeletal characters of representatives of all known fossil and recent vertebrate groups, with special reference to the temporal sequence of changing characters. I do not doubt, of course, that with further palaeontological discoveries we shall eventually be able to substitute forms that lie still nearer to the actual line of ascent from fish to man than the forms selected for our Museum exhibit. But even as it is, all recent discoveries lead to a growing confidence that we are on the right track.

WHAT IS POLYISOMERISM?

Polyisomeres may be defined as the products of budding or reduplication; they consist of a line of serially homologous parts, arranged along any axis, straight or curved. Thus polyisomerism is a more general term than metamerism, in which the serially homologous segments are arranged in an anteroposterior series. As an example of polyisomerism, we may cite the serial appendages of the trilobites. Polyisomerism is not the same as the meristic variation of Bateson, for that had reference to variations in the number of parts in a given set. Polyisomeres may give rise to anisomeres through heterogonous or differential growth of either certain members of a series or certain parts of a single organ. Anisomerism may result also from the elimination of certain polyisomeres and the fusion of some of those that remain, as in the formation of the cephalo-thorax of the crab.

Anisomeres, the changed derivatives of primitive polyisomeres, may themselves begin to bud and thus give rise to secondary polyisomeres,

or pseudo-polyisomeres. Thus secondary polyisomerism results in a process of dedifferentiation and often produces effects that deceptively resemble primitive polyisomerism. The only way to identify primary and secondary polyisomerism is to study the corresponding parts in as many as possible of the relatives of each form, and thus to trace the history of the polyisomeres or pseudo-polyisomeres under consideration.

A few illustrations of primary and secondary polyisomerism and anisomerism among the vertebrates will not only serve to give significance to these terms but may also show their possible bearings on some of the problems of anthropogeny.

POLYISOMERISM IN THE OSTRACODERMS

The origin of the vertebrates is obscured in the mists of pre-Cambrian time and after many years of heroic effort the late Professor William Patten never succeeded in convincing his colleagues that the resemblances between the arachnid eurypterids and the ostracoderms were anything more than a striking case of convergence in external appearance. The eurypterids admittedly exhibit particular combinations of polyisomerous locomotor organs with anisomerous paired cranial sense organs which point in the direction of *Limulus* and the scorpions, but I can find no sound evidence either for Professor Patten's account of the way in which the eurypterid head-shield migrated to the opposite side of the body to give rise to that of the ostracoderms, or for homologizing the so-called cranial nerves of eurypterids with those of vertebrates.

Be that as it may, it is a fact that the cranial nerves and blood-vessels of the Paleozoic ostracoderms as described by Stensiö from superbly preserved casts of the endocranial cavities and tunnels, give us a state of relatively primitive polyisomerism from which the increasingly anisomerous conditions in the higher vertebrates may readily be derived. This is combined with a marked and very early anisomerism of the paired cranial organs, which even in Silurian times had become well differentiated into paired olfactory, optic and so-called otic capsules.

The oro-branchial system of the ostracoderms was likewise polyisomerous, without any marked differentiation of the oral pouches from the remaining respiratory sacks.

The locomotor apparatus was also extremely generalized, evidently consisting of closely packed myomeres, the rhythmic contraction of

which drove the body forward in the usual way. The fins were mere projections of the skin and body-wall, serving chiefly as stabilizers rather than as active paddles. It seems important to visualize these ostracoderms as a class standing quite near to or in the main line of advance toward the higher vertebrates, culminating in man, and as representing the sort of organism from which, after a long series of changes, human conditions were eventually derived.

If we consider the axial skeleton, we find that from the time of the oldest ostracoderms up to the origin of the amphibians there was at most a moderate degree of anisomerism in the regions of the backbone and ribs. However, as the ancient mammal-like reptiles gradually learned to run with the limbs drawn in nearer to the midline, there was an increasing regional anisomerism of the backbone. Near the upper end of the series, when the immediate ancestors of man turned the backbone up at right angles to its original position, there were increasingly difficult adjustments, resulting in extreme regional anisomerism involving loss of the tail and the establishment of the lumbar curve.

POLYISOMERISM IN THE SKULL AND TEETH

The contrast between primitive polyisomerism and anisomerism is nowhere better illustrated than in the history of the skull as a whole. For in the primitive lobe-finned ganoid fishes of Devonian times, which stand practically in the line of advance to the higher vertebrates, there were no fewer than one hundred and fifty bony elements of the skull, including the branchial apparatus, whereas in the later vertebrates the number is gradually reduced, falling to twenty-eight in man.

In the dentition of vertebrates the same principles may be seen constantly in operation. In the oldest known chordates, the ostracoderms, the future teeth were represented by minute denticles which in certain forms covered the dorsal surface of the body. In the sharks the shagreen denticles around the mouth became enlarged and specialized as teeth. Then as we ascend the stages that culminate in man we find a fairly regular decrease in the total number of teeth, accompanied by regional anisomerism of those that remain, until in the Old World monkeys, anthropoid apes and man the number is reduced in the adult dentition to thirty-two.

But almost everywhere among vertebrates there are curious countercurrents of polyisomerism, which affect the small details of the more or

less anisomerous teeth of a given set and which tend to make them look alike in details although different in general pattern. Doctor Stein will present clear evidence of this tendency in man but I have seen a great many examples of it in the teeth of other mammals and in lower vertebrates. In a series of upper teeth of fossil Eocene lemuroids from ascending levels it is noticeable that as we go up the series, the last upper premolar becomes more and more like the first molar.

A good example of secondary or pseudo-polyisomerism is afforded by the dentition of the marsupial *Myrmecobius*. Here the general appearance of all the cheek teeth is markedly similar, although there is good evidence from skull structure that *Myrmecobius* has been derived from close relatives of *Thylacinus*, in which the teeth are noticeably anisomerous. It looks as if there were some pervasive influences that affect all the teeth of the growing dental lamina more or less equally.

The concept of polyisomerism and of regional anisomerism seems to include the measurable phylogenetic changes named by Professor Osborn "allometrons," "rectigradations" and "aristogenes." From the point of view of the present paper, "allometry," including a phylogenetic change in the proportionate diameter of the skull, foot, or other skeletal part, is an example of regional anisomerism; "rectigradations," such as the appearance and increase of horns of titanotheres, are localized anisomeres; "aristogenes," which are small parts like accessory conules on the teeth that gradually appear and become more numerous in certain lines of proboscideans, are examples of what I have called intradental polyisomerism, the tendency for a certain part within a tooth crown to bud or repeat itself. But I cannot see anything especially unique or mysterious in the budding of polyisomeres, and that they may often have an adaptive value is scarcely surprising.

In conclusion, physical anthropology is an exact quantitative science largely engaged in measuring homologous anisomeres in different groups. Anthropogeny, on the other hand, is an historical inquiry concerned with the succession of steps by which polyisomeres and anisomeres attained their present conditions.

JOHN FORBES'S BRITISH AND FOREIGN MEDICAL REVIEW (1836-1847) AND ITS RELATION TO MEDICAL STATISTICS*

BY WILLIAM M. GAFAFER

INTRODUCTION

ALMOST a century ago, in 1836, John Forbes (1787-1861) established a quarterly which he was pleased to name *The British and Foreign Medical Review or Quarterly Journal of Practical Medicine and Surgery.* Because of its literary merits, impartiality, honesty and scientific attitude it soon assumed the leadership of medical periodicals published in England, and its influence gradually spread over the continent. Nor was its success any less phenomenal on this side of the Atlantic. Here it came to be looked upon with genuine favor, and it was not long before a Philadelphia publisher reprinted it at his own expense. The founding of the *Review* constituted, therefore, an event of great importance in the field of scientific journalism, and because of Forbes's uncommon interest in medical statistics which is reflected in many of its pages, it unquestionably affected the development of quantitative medical thought.

Today *The British and Foreign Medical Review* is conspicuously absent from the various lists of references usually attached to scientific papers and books. In addition, no standard work of the present century on the history of medicine could be found whose index contained the *Review* or the name of its editor. And the same applies to the historical literature of the present century dealing with quantitative science. Finally, in bibliographical circles allusions to the *Review* or its editor are rarely made.[1]

* Paper No. 176 from the Department of Biostatistics, School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, Maryland.

The terms "numerical method" and "statistical method" are used synonomously in this paper.

[1] *The Encyclopædia Britannica,* 11th ed., devotes three inches to Forbes; in the 14th ed. his biography does not appear. Power and Thompson's *Chronologia Medica,* 1923, makes no mention of either *Review* or editor. E. W. Goodall, "William Budd: A Forgotten Epidemiologist," *Proc. Roy. Soc. Med., 25,* 277-294, 1931-32, refers briefly to both.

It is hardly necessary to include further introductory details. It is sufficient to add that it is proposed to present, first, a brief chronological sketch of the life of Forbes; second, a bibliographical description of the *Review*, and, finally, evidence, by means of a suitable quotation from the *Review*, of the interest of Forbes in the numerical method.

JOHN FORBES (1787-1861)[2]

The editor and proprietor of *The British and Foreign Medical Review* was born in 1787 at Cuttlebrae in the parish of Ruthven, Banffshire, Scotland, the fourth son of Alexander Forbes. After the usual discipline of a village school followed by three years at Fordyce Academy and a year at the Aberdeen grammar school, he entered Marischal College, Aberdeen, in 1803, where he remained until 1806. Subsequently he was granted the diploma in surgery, by Edinburgh, and in 1807 he entered the navy, serving for nine years as assistant surgeon, and later as surgeon, chiefly in the North Sea and in the West Indies. In 1817 he graduated M. D. at Edinburgh. On the advice of Professor Jameson whose geological lectures he attended at Edinburgh and who had been requested to recommend a physician with an acquaintance with geology, he removed to Penzance, Cornwall, where he succeeded J. A. Paris and devoted the greater part of his time to geological and meteorological investigations. During the last year (1821) of his residence here he introduced the doctrines of physical

[2] For additional biographical and bibliographical material see: A. C. P. Callisen, *Medicinisches Schriftsteller-Lexicon*, v. 6, 1831 and v. 28, 1840; *Index-Catalogue of the Library of the Surgeon-General's Office, United States Army*, ser. 1 and 2; *Alphabetical Catalogue of the Library of the Faculty of Physicians and Surgeons of Glasgow; Dictionnaire Encyclopédique des Sciences Médicales*, ser. 4, v. 3, 1879; *Dictionary of National Biography*, v. 7, 1908; *M. Times & Gaz., 2*, 504-507, 534-535, 1861; *Lancet, 2*, 512, 1861; *Brit. M. J., 2*, 561-562, 675 [will of Forbes], 1861; *Wien. med. Wchnschr., 11*, 789, 1861; *Brit. & For. M.-Chir. Rev.* [successor to Forbes's *Review*], *29*, 271-282, 1862; *Edinburgh M. J., 7*, 603-604, 1861-1862; *Proc. Roy. Soc., 12*, vi-xi, 1862-1863; J. R. Russell, *The History and Heroes of the Art of Medicine*, 8vo, London (John Murray), 1861; W. T. Gairdner, *The Physician as Naturalist*, 8vo, Glasgow (James Maclehose & Sons), 1889; A. Wilder, *History of Medicine*, 8vo, Augusta (Maine Farmer Pub. Co.), new ed., 1904.

See also, F. H. Garrison, "Available Sources and Future Prospects of Medical Biography," *Bull. N. Y. Acad. Med., 4*, 586-607, 1928.

diagnosis by publishing a translation of Laennec's work on auscultation [3] with a description of the newly invented stethoscope.

In 1822 Forbes settled in Chichester, Sussex, as the successor of Sir W. Burnett where the friendship was formed with John Conolly that led to their subsequent association in the publication (with Alexander Tweedie) of the four-volume *Cyclopædia of Practical Medicine,* 1833-1835,[4] and in the publication of the first few numbers of the *Review,* 1836-1847. An extensive medical bibliography compiled by

FIG. 1. SIR JOHN FORBES (1787-1861), M. D., F.R.S., F.R.C.P., D.C.L. (OXON.), ETC.

[3] *A Treatise on the Diseases of the Chest and on Mediate Auscultation, by R. T. H. Laennec. Translated from the latest French Edition with Copious Notes and a Sketch of the Author's Life, by John Forbes,* 8vo, London (Longmans and others), 4th ed., 1834.

[4] Reviewed in *Brit. & For. M. Rev., 1,* 176-182, 1836. This review is in reality an essay on the bibliography of medical dictionaries and cyclopædias. The London edition of the *Cyclopædia* was revised by Robley Dunglison and appeared in Philadelphia (Lea and Blanchard) in four volumes, octavo, in 1845.

Forbes forms an appendix to the last volume of the London edition of the *Cyclopædia*; this list was republished separately with additions in 1835.[5] In 1824 Forbes translated Auenbrugger's treatise of ninety-five pages on the percussion of the chest [6] which had appeared in Vienna over sixty years previously. The year 1840 found him established in London where he felt he could better direct the *Review*. Three years later he became the chief organizer of the Sydenham Society which had for its object the reprinting of important inaccessible medical works. The story told by Jonathan Hutchinson concerning the last meeting of the Sydenham Society and the birth of its successor, the New Sydenham Society, is particularly appropriate to reprint at this time:

> At the concluding meeting of the old Sydenham Society Sir John Forbes was in the chair and when the resolution which closed its life was proposed, I ventured to speak in opposition to this step, my chief argument being that although the Society had possibly completed its work as regards classical literature, there was still a wide and useful field for it in respect to translations from modern continental works. I had, perhaps, urged my point with too much insistence, and Sir John Forbes finally closed the discussion, put the matter to vote, and addressing himself to me pointedly, remarked "that if some young men thought the Society's work was not finished, they had better form a new one for themselves." The closing resolution was carried, I believe, unanimously, with the exception of my own vote.[7]

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[5] *A Manual of Select Medical Bibliography, in which the Books are Arranged Chronologically According to the Subjects; and the Derivations of the Terms, and the Nosological and Vernacular Synonyms of the Diseases are Given; With an Appendix, Containing Lists of the Collected Works of Authors, Systematic Treatises on Medicine, Transactions of Societies, Journals, etc., etc.*, viii + 403 pp., 8vo, London (Sherwood, Gilbert & Piper), 1835. A review including excerpts from the *Bibliography* appeared in *Brit. & For. M. Rev.*, *1*, 513-517, 1836. The *Bibliography* was omitted from the Philadelphia edition of the *Cyclopædia*.

[6] *Original Cases, with Dissections and Observations, Illustrating the Use of the Stethoscope and Percussion in the Diagnosis of Diseases of the Chest; also Commentaries on the Same Subjects Selected and Translated from Auenbrugger, Corvisart, Laennec and Others*, 8vo, London (T. & G. Underwood), 1824. See also, M. Neuburger, *Leopold Auenbruggers* INVENTUM NOVUM, *Faksimile nach der ersten Ausgabe [Vienna, 1761], begleitet von der französischen Uebersetzung Corvisarts [Paris, 1808], der englischen von Forbes [London, 1824], der deutschen von Ungar [Vienna, 1843], . . . mit einer biographischen Skizze*, 8vo, Vienna and Leipzig (Josef Safář), 1922.

[7] J. Hutchinson, *The New Sydenham Society: Retrospective Memoranda*, 8vo, London (H. K. Lewis), 1911; p. 2. See also, the *Index-Catalogue*, ser. 1 and 2, under *Sydenham Society; Brit. M. J.*, *1*, 545, 1901 (printed also in *Lancet*, *1*, 661-

The Sydenham Society was dissolved in 1858. The New Sydenham Society was instituted in the same year, and issued its last work in 1907.

At the close of 1847 Forbes gave up the *Review* giving as his reasons that he was sixty years of age, and that the work was too much for him. His last publication, *Of Nature and Art in the Cure of Diseases,* appeared in duodecimo in 1857, and was "bequeathed as a legacy to his younger brethren." In it he gave his ideas on the nature of diseases emphasizing their curability by the power of nature alone.[8] Not long after the appearance of this book he began to suffer ill health. He left London in 1859, and died at Whitchurch near Reading in 1861 in the seventy-fourth year of his age.

The likeness of Forbes appearing as Fig. 1 is reproduced from a woodcut published in a paper by Thomas Laycock.[9]

THE REVIEW (1836-1847)

Before the completion of the *Cyclopædia* Forbes planned the publication of *The British and Foreign Medical Review* which was to be a continuation, with improvements, of *The Medical Quarterly Review.*[10] The first number consisting of 312 pages, two plates and three figures appeared on January 1, 1836, and was not too favorably reviewed in the *Lancet* of January 16. There were four departments: "Analytical and Critical Reviews," 164 pages including 6 articles on 8 books; "Bibliographical Notices," 66 pages including 13 articles on 18 books and one article giving bibliographical descriptions of 19 foreign journals; "Selections from Foreign Journals," 58 pages including 33 abstracts, and "Medical Intelligence," 20 pages. The last four pages of the number were devoted to a list of original papers published in 5 British

662, 1901); and the *Appendix* volume of Lowndes's *The Bibliographer's Manual* under *Sydenham Society* and *New Sydenham Society.*

Reference must be made in passing to Hutchinson's *The Pedigree of Disease; Being Six Lectures on Temperament, Idiosyncrasy and Diathesis,* 8vo, London (J. & A. Churchill), 1884.

[8] Reviewed in, *N. Am. M.-Chir. Rev., 2,* 800-807, 1858.

See M. Neuburger, *Die Lehre von der Heilkraft der Natur im Wandel der Zeiten,* 8vo, Stuttgart (Ferdinand Enke), 1926; and the critical notices of the contemporary press reprinted in Forbes's book.

[9] "Physiognomical Diagnosis of Disease," Lecture 3, *M. Times & Gaz., 1,* 103, 1862.

[10] Four volumes of this *Quarterly* were issued between October, 1833 and July, 1835. The editors were J. North and G. F. Burnett.

journals during the last quarter, and to a list of 48 books received for review. In subsequent numbers several pages were given to obituaries. Two numbers constituted an octavo volume, and two volumes appeared annually. The last number of the *Review* was published in October, 1847.

After Forbes's resignation the *Review* was bought by John Churchill, its publisher, and incorporated with Johnson's *Medico-Chirurgical Review,* Forbes's old opponent. The first number of the combined reviews, *The British and Foreign Medico-Chirurgical Review,*[11] was issued in January, 1848, and publication continued through October, 1877. In October of 1848 Forbes published a complete general index, designated *Volume 25,* to the preceding 24 volumes of his *Review* arranged according to author and subject in one alphabet; the work is a most valuable reference book covering, as it does, a distinguished period of 12 years of medical life and literature.[12]

One of the title pages of the *Review* has been reproduced and appears as Fig. 2.

QUOTATION

The outstanding characteristic of Forbes was the natural, healthy scepticism of the genuine scientist. He was dissatisfied with and rebelled against the loose reasoning that pervaded most of the medical

[11] Indexed in Richard Neale, *The Medical Digest,* 8vo, London (The New Sydenham Society), 1877; 2 ed., 1882.

[12] In connection with this Section, see the "Postscript" written by Forbes and published in the last number of the *Review* (*24,* 585-598, 1847) for an excellent and informative exposition of, first, the deficiencies of the medical press at and before the time of the establishment of the *Review;* second, the underlying principles of the conduct of the *Review;* third, the means used to carry out these principles, and fourth, the facts, including figures, relating to circulation, receipts and expenditures.

For the effect on the fortunes of the *Review* of the publication of Forbes's celebrated article, "Homœopathy, Allopathy, and 'Young Physic'" (*21,* 225-265, 1846), see *Brit. & For. M.-Chir. Rev., 29,* 280-281, 1862. Further comments on Forbes's paper may be found in, among others, *Brit. & For. M. Rev., 21,* 501-532, 1846; E. Bartlett, *An Inquiry into the Degree of Certainty in Medicine,* 8vo, Philadelphia (Lea and Blanchard), 1848; H. I. Bowditch, "Address on Hygiene and Preventive Medicine," *Transactions of the International Medical Congress of Philadelphia, 1876,* 1877, p. 25; and, E. H. Sieveking, "Address in Medicine," *Brit. M. J., 2,* 175, 1876. Bartlett records that Forbes has taken "a partial view of his subject." Both Bowditch and Sieveking refer to the article favorably; the latter considers it an event connected with the scientific advancement of medicine in England.

THE

BRITISH AND FOREIGN

MEDICAL REVIEW

OR

QUARTERLY JOURNAL

OF

PRACTICAL MEDICINE AND SURGERY

EDITED BY

JOHN FORBES · M.D. F.R.S. F.G.S.

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LONDON

JOHN CHURCHILL PRINCES STREET SOHO

MDCCCXLVI.

FIG. 2. TITLE PAGE OF VOLUME TWENTY-ONE OF FORBES'S REVIEW
(Slightly reduced)

thought of his day. He attacked error constantly, and especially the *post hoc ergo propter hoc* conclusions that formed a part of many of the addresses and papers which came to his attention. With this type of mind it is not difficult to understand why Forbes translated Laennec and Auenbrugger, and why he became interested in the numerical method as introduced into the medical literature by P. C. A. Louis [13] and his students. It is easy to see why he devoted so much space of the *Review* to the work of Louis and other advocates of the numerical method, and why one of the earliest books issued (1844) by The Sydenham Society was the translation by Walshe of Louis's *Researches on Phthisis*.[14] And his article, "Homœopathy, Allopathy and 'Young Physic,'" was essentially an appeal for the introduction of the scientific method into medicine; here his proposition 4 states that, *The general adoption by practitioners in recording their experience of the system known by the name of the* NUMERICAL METHOD *is essential to the attainment of the ends proposed* [*in this paper*].[15] It has already been implied (footnote 12) that the paper in which this statement occurs provoked both favorable and unfavorable comments among the readers of the *Review*. Thomas Laycock's answer to proposition 4 in a letter to Forbes is of more than ordinary interest and reads as follows:

> With regard to proposition 4, I advance as the result of my experience in vital statistics, that the numerical method is one not as yet *generally* applicable to medical observations; or, if generally applicable, only in points of detail so simple in character that they scarcely require it for their elucidation, except to those who wish for a numerical expression of facts. In the first place you want skilled observers; you want a regiment of *trained* men—trained, too, in the same school, at the same drill—so that, whether their observations be right or wrong, they will be alike right and wrong. You know well the difficulty of minute diagnosis; how much skill is required to tabulate effectually according to the inductive method (for this is the true principle of the numerical method) those cases of which you have no doubt; and under the most favorable circumstances for observation how many links in the chain of phenomena to be observed and classed cannot be made out at all. Pray observe I am not giving an opinion adverse to the numerical

[13] It is a remarkable coincidence that Forbes and Louis were born in the same year, 1787. Louis died in 1872, outliving Forbes eleven years.

See A. Flint, "Remarks on the Numerical System of Louis," *N. York J. M. & S.*, *4*, 283-303, 1841; also W. Osler, "The Influence of Louis on American Medicine," *An Alabama Student and other Biographical Essays*, 8vo, Oxford (Clarendon Press), 1908.

[14] See Louis's remarks on, and references to the numerical method, pp. xi-xxx.

[15] *Loc. cit.*, p. 262.

method, because I am sure it is a truly scientific method. What I advance is, that as yet it cannot be made *generally* applicable.[16]

Both Bowditch [17] and Sieveking [18] recognized the appeal of Forbes for a more rational medicine. The former, for example, discusses Forbes in a Section with the significant caption: "Epoch [1832-1869] of Observation and Accurate Recording and Subsequent Analysis of Facts; With an Extreme Confidence in Nature's Power in Disease; A Corresponding Scepticism in Regard to the Use of Drugs; and, Finally, Dim Presages of Preventive Medicine."

We turn now to the matter of the quotation. One could with very little difficulty find sufficient material in the *Review* dealing with various aspects of the numerical method to fill a small readable volume. With the limited space at our disposal, however, it is possible to present either a review with some omissions, or a number of appropriate excerpts from several reviews. It has been decided to follow the first course of action. Accordingly, we have chosen the anonymous [19] review of Jules Gavarret's work on medical statistics.[20]

The first half of the article deals principally with the cause of the imperfection of medical science and is based, according to the author, on

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[16] "On the Methods for Obtaining a Natural History of Diseases," In a Letter to the Editor, *Brit. & For. M. Rev., 21,* 525, 1846. The entire letter (525-532) is worth reading.

[17] *Loc. cit.,* p. 23.

[18] *Loc. cit.,* p. 175.

[19] All of the reviews were anonymous. Forbes inserted in his own copy of the *Review* the names of the authors, and that copy he left at his death to his "good friend and faithful publisher, Mr. Churchill, as a small mark of esteem and regard." See *Brit. & For. M.-Chir. Rev., 29,* 280, 1862, an anonymous paper written according to Greenhill (see *D. N. B.* under FORBES) by E. A. Parkes.

Parkes records in his article, page 279, that the publisher's marked copy discloses the fact that some of the statistical reviews were contributed by William Farr (1807-1883), "the founder of modern medical statistics." Farr was appointed compiler of abstracts in the General Register Office (London) on July 10, 1839. See N. A. Humphreys, *Vital Statistics: A Memorial Volume of Selections from the Reports and Writings of William Farr,* 8vo, London (Edward Stanford), 1885; two papers on Farr by M. Greenwood, *Proc. Roy. Soc. Med., 25,* 1-6, 1931-32, and *Lancet, 224,* 1047-1052, 1933; and "Medical Statistics," *Ibid., 200,* 985-988, 1921. See also the references under FARR in the index volume of *Brit. & For. M. Rev.*

[20] *Principes généraux de Statistique médicale ou Développement des Règles qui doivent présider à son Emploi,* xvi + 312 pp., 8vo, Paris (Bechet Jeune et Labé), 1840. Reviewed in *Brit. & For. M. Rev., 12,* 1-21, 1841.

a paper by Guy.[21] The reviewer continues with an exposition of the meaning and origin of the term "statistics," and then gives an example of the numerical method which reads as follows:

> We now turn to the more interesting and important subject of events brought about by a great number of conjoint causes, all of which may vary within wide limits of intensity in the several instances observed; and where the object is to collect and express numerically the frequency of the events in question.
>
> As an example of such events we will take the alternative of death or recovery, the consequence of a given method of treatment in a given form of disease. Here the causes which combine to bring about the one or the other of these two events are extremely numerous. Gavarret divides them into five distinct groups, as follows:
>
> 1. *Individual conditions.* Age, sex, temperament, constitution, previous diseases, and state of health at the time of the invasion of the disease in question.
>
> 2. *Hygienic conditions antecedent to the invasion of the disease.* Profession, social position, mode of life, ventilation, state of dwelling, kind of nourishment, moral influences.
>
> 3. *Hygienic conditions during the treatment.* Healthiness of the place in which the patient is treated, moral influences which act upon him during the course of his disease, and the exactness with which the orders of the medical attendant are followed.

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[21] W. A. Guy, "On the Value of the Numerical Method as Applied to Science, but especially to Physiology and Medicine," *J. Roy. Stat. Soc., 2,* 25-47, 1839. Compare, D. W. Cheever, "The Value and the Fallacy of Statistics in the Observation of Disease," (A Boylston Prize Essay), *Boston M. & S. J., 63,* 449-456, 476-483, 497-503, 512-517, 535-541, 1861.

In connection with this Section see, E. Bartlett, *An Essay on the Philosophy of Medical Science,* 4to, Philadelphia (Lea & Blanchard), 1844; W. A. Guy, "On the Original and Acquired Meaning of the Term 'Statistics,' and on the Proper Functions of a Statistical Society, etc.," *J. Roy. Stat. Soc., 28,* 478-493, 1865; W. Hooper, "The Method of Statistical Analysis," *Ibid., 44,* 31-49, 1881; J. S. Billings, "Our Medical Literature," pp. 63-67, *Transactions of the VII* [*London*] *International Medical Congress,* v. 1, 54-71, 1881; Idem, "On Vital and Medical Statistics," (The Cartwright Lectures), *Med. Rec., 36,* 589-601, 617-627, 645-656, 1889; bibliography of 171 titles appended to F. H. Garrison, *John Shaw Billings, A Memoir,* 8vo, New York and London (G. P. Putnam's Sons), 1915; M. Greenwood, "On Methods of Research Available in the Study of Medical Problems," *Lancet, 1,* 158-165, 1913; and H. L. Dunn, "Application of Statistical Methods in Physiology," [bibliography of 768 titles], *Physiol. Rev., 9,* 275-398, 1929.

See also, C. F. Bolduan, "Hospital Morbidity Statistics," *New York Med. J., 97,* 643-646, 1913; R. Pearl, "Modern Methods in Handling Hospital Statistics," *Bull. Johns Hopkins Hosp., 32,* 184-194, 1921; and H. L. Dunn, "Prospectus of Minnesota Hospital Statistical Bureau," *Journal-Lancet, 54,* 148-156 + A-O, 1934.

4. *The disease itself.* Nature of the disease, extent and degree of organic lesions, and of the influences which they exert on the economy, period which elapses between the attack of the disease and the commencement of the treatment, and the several complications which may arise in the course of the disease.

5. *Treatment employed.* This head includes not merely the remedy made use of, but the dose administered, and the various auxiliary remedies used to meet occasional symptoms.

It would perhaps be possible to extend this list on the one hand, and to simplify it on the other; but assuming that it is a tolerably correct representation of the several circumstances which may affect the success of a plan of treatment adopted in any given disease, it must be obvious that, if the disease in question be one of any severity, the event of it may be greatly influenced by any one of these several circumstances, and as it is altogether impossible to estimate the influence which they would severally exert, we must rest contented with an accurate observation of the result obtained in all the instances. Confining our attention, therefore, to the result, what are the rules which are to guide us in obtaining that result, and in applying our knowledge of it to the prediction of the fate of patients laboring under the same malady?

The first thing to be attended to is the quality of our observations, the second is their number. It is obvious that we can scarcely err with regard to the mere event, provided we take the most ordinary degree of pains: in this it will be easy to make all our observations strictly comparable. But there is ample room for error in the selection of our cases, and in the circumstances under which we place our patients during the course of their malady. The disease may be loosely defined, and we may confound together cases of a totally different nature, or we may be calling a mere symptom a disease, and thus throw together under the same title things in themselves essentially different. . . . The observations, then, which we group together under the same name, must be strictly comparable facts, in order that our conclusions may have any value.

But not only must the diseases which we call by the same name be the same things, own the same causes, and have the same things in common, but the circumstances under which our patients are placed must be, as far as possible, the same. They must occupy the same locality, receive the same attention, partake of the same diet, and, as far as practicable, be placed under the same treatment.

Those things, then, which are in the power of the physician must be made the same in all the cases observed, or the result must needs be faulty. But those circumstances over which the physician has control form but a small part of the influences brought to bear on the several subjects of his observations: there still remains a long list of circumstances peculiar to each individual over which the physician can exercise no control, and these must have a powerful effect on the result of his treatment. The existence of such individual peculiarities precludes the possibility of meeting with any strictly comparable facts, and this circumstance has been unjustly advanced as an objection against the application of numbers to medical enquiries. This objection goes on the mistaken supposition, that numbers being made up of units can have no value, unless the units themselves be absolutely identical. The answer to this objection is at once supplied by the fact already stated, that the astronomer is constantly making use of measurements not strictly

comparable, and applying to those measurements the numerical method which we are now advocating. Insurance societies of all kinds are constantly making the most important use of events brought about by causes not less variable and entangled than those of which we now speak, and the results which they attain justify their calculations. By parity of reasoning, then, the physician may expect to derive advantage from grouping together observations not absolutely comparable, and applying to them the same calculations which his experience teaches him lead in the hands of others to true and valuable results. With regard, then, to the quality of our facts, it is sufficient that they be strictly comparable in those particulars over which we can exercise control. . . .

The first principle on which our author insists is, that the number of our observations should be considerable. Now this principle will be readily conceded, for every day's experience convinces us that a small number of observations is altogether insufficient to establish any result whatever on a firm basis, whilst on the other hand it shows the sufficiency of very considerable numbers. . . .

Assuming, then, that the necessity for employing large numbers of comparable facts in forming general conclusions will be readily conceded, the next question which arises is, how many facts will be sufficient to establish such a general result as the efficacy or inefficacy of a given plan of treatment in a given disease? Our readers must not be disheartened when they are told, that even the most industrious observers of the present day have fallen very far short of the strict requirements of the numerical method, and the indications afforded by the calculus of probabilities. M. Louis, the justly celebrated medical statistician, falls under our author's censure for having asserted the slight efficacy of bleeding in pneumonia, erysipelas of the face, and cynanche tonsillaris, on the strength of 100 cases of the first disease, 44 of the second, and 23 of the third, and he lays it down as an undoubted principle that "every *statistique*, in order to furnish admissible indications, ought to consist of *many hundreds of observations*." If Louis, to whom the profession is under such obligations for taking the lead in this grand improvement lies open to censure, what shall we say of the majority of his followers, and in what terms shall we speak of those who still persist in foregoing the aid of numbers, and in drawing important conclusions from one or two scattered, and not comparable facts. To bring together such large numbers of observations is, in the present state of medical science, and with the existing opportunities and industry of medical men, impossible: hence it is most important to discover some means by which we may know the degree of reliance to be placed upon smaller numbers of observations, and within what limits the results derived from such small numbers may be looked upon as entitled to confidence.

. . . where an event has been *observed* to happen a certain number of times in a given number of cases, the probability of its happening is not represented by the actual number observed, but lies between limits somewhat greater and somewhat less than that number; and . . . these limits vary with the number of observations, being wider as the observations are few in number, and approaching each other more and more as they increase. . . .

Examples illustrating the determination of the standard deviation of a ratio, and a summary conclude the review. The summary reads as follows:

The object of the foregoing remarks is to make the more perfect sciences an example to our own. By showing how important a part calculation plays in those sciences which have attained the highest degree of perfection, we think that we have pointed out the true path to the improvement of the science of medicine. The substitution of figures for words, though a step gained, is not all that is required: the numbers which we deal with must be large ones, and where they are not so, we must make allowances for error proportioned to the number of our observations. To make the principles of our science as close approximations to truth as possible, the facts from which those principles are deduced must be very numerous. Where objects are to be examined of variable magnitude, we must make as many observations as shall include all the varieties which nature presents; where events are the subjects of our enquiry we must collect as many instances as shall enable us to find at least very close approximations to the actual frequency of their occurrence. But the units of which our numbers consist must be comparable facts. Where to obtain these facts is the difficulty. How few men possess the opportunity, how very few the inclination to make such large collections of facts! and what reward can they expect for their industry? The *practical* man who delights in single cases, and glories in those who deal with them, will laugh to scorn the plodding collector of facts by the hundred, and confound the principles which he draws from them with the hypotheses of some dreaming enthusiast. . . .

Once more, then, the SCIENCE OF MEDICINE wants facts—comparable facts—numerous facts: well observed, carefully arranged, minutely classified, and acutely analyzed. Her language must be the language of figures; her test, the calculus of probabilities; her example, the most perfect and exact among the sciences of observation and experiment.

It was one of the editor's invariable rules to read over carefully the manuscripts of all articles, and it was always an understanding formally come to between him and the contributors, that he should reserve to himself the power of altering articles by omission, addition or otherwise.[22] It is remarkable that Forbes who was not a polypharmacist in any sense of the word did not supplement the Gavarret review with some reflections on the value of a control group. It is only fair to say, however, that such reflections are introduced in other quantitative reviews.[23]

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[22] "Postscript," *loc. cit.*, p. 587.

[23] See, for example, the reviews of Henle, *Manual of Rational Pathology, 24,* 289-321, 1847, and Louis, *Typhoid Fever, 12,* 22-53, 1841.

STUDIES ON CONSTITUTION

II. SOMATOLOGICAL DIFFERENCES ASSOCIATED WITH DISEASES OF THE HEART IN WHITE MALES[1]

BY RAYMOND PEARL AND ANTONIO CIOCCO

INTRODUCTION

THE study of human constitution has for one of its major objectives the discovery of stable organic correlations (integrated biological relations) between the morphological, physiological, psychological, and pathological characteristics of the individual, and eventually the precise numerical measurement of such correlations (24, 27, 33).[2] In particular, with regard to the relation between somatic constitution and disease, it seeks the degree of consilience between variation in morphology and in normal or pathologic physiology; and the part this plays in predisposition and different individual reactions to infections and other diseases (10).

Morphologic variation in man is roughly expressed in terms of the preponderance of the vertical or horizontal dimensions. This leads to the usual classification of body habitus: Asthenic, Intermediate, and Pyknic,[3] which represents a triple division of the continuous frequency distribution having at one extreme individuals in whom the vertical dimensions are a relative maximum and the horizontals a minimum (asthenics), and at the other those in whom this relation is reversed

[1] From the Department of Biology of the School of Hygiene and Public Health of the Johns Hopkins University.

[2] This point of view is not necessarily wholly out of harmony with that of the "genetic school" of constitutionalists represented by Martius (20) and Bauer (3), though we find ourselves unable to accept some of their more extreme and really purely speculative concepts. Cf. the comparison and critical analysis in Pearl (24) and Viola (33).

[3] Almost every student of constitution has adopted a different terminology for the three types. The above are those commonly used in American literature, and have been adopted as standard usage in this laboratory.

(pyknics). The idea of the continuity in the variation of man in bodily habitus has not always been given due consideration although it forms the theoretical foundation of Viola's methodology, and is emphasized especially by Pearl.

Typing individuals as to somatic habitus is done by visual inspection and mental comparison with an ideal average (judgment), or by a series of measurements that directly or indirectly (through indices) are considered sufficient to achieve this end (10, 33). With either of these methods it is the *variation* of the total bodily structure that one observes or relates to that of the functional state. Besides this synthetic view, it is also essential ultimately to know the differential development of the segments and parts of the body relative to themselves as well as to the soma as a whole. This knowledge is especially important for those problems dealing with the interrelation between internal anatomical structure and external morphology.

The use of indices in somatological analysis is not wholly satisfactory because their significance is limited by the inadequacy of the measurements used and the form in which they are expressed (16, 19). One method of approach to this aspect of the problem which is derived as a logical consequence of our definition, and offers the possibility of useful extension, is that of statistical correlation of the body dimensions. This has been done for a few characters by Ruger (30, 31) and Brezina and Wastl (7), and it is one of the major objectives of the present investigation. The results will appear in a later publication.

The influence of constitution on disease has always been recognized,[4] at times underrated, at times unduly magnified. Since the fundamental work of Beneke (5, 6) numerous observations have been made. The most definite and conclusive evidence indicates that (a) the asthenic individual is frequently afflicted with hyperthyroidism and tends to be predisposed to tuberculosis, nervous instability, dyspepsia, presbyacusia, and schizophrenia; (b) the pyknic, on the other hand, often has thyroid deficiency, and is prone to cerebral hemorrhages, hypertension, arthritism, and cyclothymia. These predispositions inherent to the somatic constitution have been newly confirmed by the recent statistical study from this laboratory by Freeman (14) on 1260 autopsies of psychiatric patients. That author also notes that the intermediate constitutional

[4] Cf. the very interesting article by Barbára (2) comparing Pende's constitutional types with the fourfold classification of the humoral school.

type is associated with paranoia and a tendency to malignancies and to chronic streptococcus infection; dysplasia is found by him frequently combined with epilepsy and various forms of exudative diseases.

THE MATERIAL AND THE PROBLEM

This study is based on the records of clinical and anthropometric observations made under the direction of Raymond Pearl at the Institute for Biological Research (now the Department of Biology of the School of Hygiene and Public Health) of the Johns Hopkins University. The history of the organization and the technique used have been amply described (26), and need not be repeated here.

For the purposes of the present investigation we have divided the males (all white) in the material into two groups according to the results of the clinical examinations. In one group are those patients who *at the time of examination* gave no clinical evidence of cardiac disease, in the other those that *at the time* gave clinical manifestations of cardiac disease, mild or grave as the case might be. In a number of cases the clinical diagnosis has subsequently been confirmed at autopsy. The males with whom we are concerned in this paper number 245. Of these 133 are non-cardiacs and 112 are cardiacs.

The basic problem with which this study is concerned is: *What, if any, significant somatological differences are there between the cardiacs and the non-cardiacs in this material?*

The object of the study is thus evidently purely descriptive. It is a contribution to the not particularly exciting, but, as has been emphasized (24), absolutely necessary spade work essential to the laying of a sound foundation to a true science of human constitution.

AGE DISTRIBUTION

The incidence of heart disease, taking all forms together, increases with age. In the primary selection of our material we included only adults, aged 20 years or over.

The biometric constants relative to age for the whole material are as follows:

	Cardiacs	*Non-cardiacs*
Mean age.....	53.04± .76 years	33.57± .69 years
Standard deviation	11.97± .54 years	11.77± .49 years
N	112	133

It is at once evident that the two groups are not remotely homogeneous in respect of age, and that, from the viewpoint of sound biometric methodology, comparisons between them would, on that account, be of doubtful significance. Consequently we have felt compelled to confine the study to persons falling between the ages of 40 and 69 years, inclusive. This reduces the numbers rather seriously, but at the start homogeneity is clearly more important than numbers.

The biometric constants for age of the reduced groups, with which the remainder of this paper down to the penultimate section will deal, are as follows:

	Cardiacs	*Non-cardiacs*
Mean age	53.62± .50 years	49.80± .57 years
Standard deviation	6.92± .35 years	6.71± .45 years
N	87	50

It is evident that the smaller groups, while still probably significantly different from one another in mean age, are so by only a relatively small amount, too small to make any appreciable difference in any conclusion regarding somatological characters.

PATHOLOGY

Table 1 shows the absolute and percentage distributions of the disease conditions diagnosed in the two groups, classified into broad categories. There are two reasons for considering these data. The first is that it will aid in the formation of a judgment of the extent to which the two groups may be differentiated somatologically by reason of differential incidence of pathological conditions which seriously alter the nutritional condition of the patient. The second is that the pathological panel *per se* is a most important part of the whole constitutional picture. We wish to see in some detail how these two groups are differentiated in this respect.

It is to be noted that the percentage columns of Table 1 will not add to 100 because each patient has been entered separately for all the pathology exhibited, within the categories of the classification. Thus some of the 22 individuals with myocardial insufficiency also were arteriosclerotic and were entered under both categories.

As would be expected *nephritis* is relatively much more prevalent in the cardiac than in the non-cardiac group. Over a half of the cardiac group exhibited *other diseases of the circulatory system (arterioscle-*

TABLE 1

Distributions of Diagnosed Pathological Conditions

PATHOLOGICAL CONDITION	NON-CARDIACS		CARDIACS	
	Absolute number	Per cent	Absolute number	Per cent
Normal (no discernible pathology)	4	8.0	..	...
Heart—Hypertrophy and dilatation	..	...	27	31.0
Heart—Myocarditis	..	...	22	25.3
Heart—Endocarditis and valvular lesions	..	...	12	13.8
Heart—Aortic dilatation	..	...	9	10.3
Heart—Other lesions	..	...	17	19.5
Other circulatory diseases (arteriosclerosis, etc.)	..	...	48	55.2
Nephritis—all forms	1	2.0	12	13.7
Syphilis—all forms	12	24.0	14	16.0
Tuberculosis	1	2.0	2	2.3
Cancer of alimentary tract	7	14.0	13	14.9
Other malignant tumors	10	20.0	7	8.0
Pneumonia (all forms), bronchitis, etc.	2	4.0	6	6.9
Diseases of alimentary tract (other than cancer and tuberculosis)	4	8.0	3	3.4
Diabetes	1	2.0	6	6.9
Diseases of gall bladder and ducts	2	4.0	2	2.3
Arthritis	1	2.0	..	...
All others	7	14.0	..	...

rosis, etc.) in addition to their cardiac lesions. This is in striking contrast to the non-cardiac group, where there was no incidence of either heart or circulatory lesions or diseases. *Syphilis* (chiefly neuro-syphilis) was relatively more prevalent in the non-cardiacs than in the cardiac group. The same is true of *diseases of the alimentary tract, diseases of the gall bladder and ducts,* and the *All other diseases* category.

Cancer of the alimentary tract, an important pathological category in the age period dealt with, exhibits approximately the same relative frequency in both groups. But *Other malignant tumors* are more than twice as frequent relatively in the non-cardiac group as they are in the cardiac group. Taking all malignancy together 34 per cent of the non-cardiacs were so afflicted, as against 22.9 per cent of the cardiacs.

Diabetes occurs more frequently relatively in the cardiac group. *Tuberculosis* and *pneumonia* are but slightly and about equally represented in both groups.

Summing the whole matter up it appears that we are comparing two groups of individuals, one of which, the cardiacs, is characterized pathologically as a group by a 100 per cent incidence of heart lesions, together with a relatively high incidence of arteriosclerosis, nephritis and diabetes. The other (non-cardiac) group in contrast exhibits as a group no lesions of heart or circulatory system, practically no nephritis or diabetes, but relatively more syphilis and malignancy.

It should be clearly understood that these are selected groups, and that the relative incidence of the various disease categories listed cannot be regarded, for either group, as that of the general population within the same age limits. To draw any statistical conclusion on the supposition that either of our groups is a random sample of the general population would be extremely fallacious. All that we are attempting to do is to compare two *defined* samples.

DIRECT ANTHROPOMETRIC MEASUREMENTS

Table 2 presents the mean, median, standard deviation, coefficient of variation, minimum observation, maximum observation, and range of variation, for each of the 22 somatic variables directly measured upon the living subject and discussed in this paper. For each variable the unit of measurement and the number of individuals measured are indicated.

From Table 2 the following points are to be noted:

1. In all of the five height measurements the non-cardiac group exhibits slightly higher mean values, but in no case can the difference be regarded as even probably significant statistically, having regard to its probable error. Hence it must be concluded that the two compared groups may be regarded for all practical purposes as of the same average height, considered as groups. In Trunk Length the cardiac group shows a slightly greater mean value, but again too small to be significant statistically.

2. While, as has been seen, the two groups are of substantially the same average height, the cardiacs have a mean Body Weight 6.36 ± 1.55 kg. (14.02 ± 3.42 lbs.) *greater* than the non-cardiacs. This difference is real and considerable, amounting to a 9.8 per cent average increase

TABLE 2

Biometric Constants of Direct Somatic Measurements

(Males 40-69 years of age)

CHARACTER	*N*	MEAN	MEDIAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MINIMUM OBS.	MAXIMUM OBS.	RANGE
Body weight (kg.)								
Cardiacs	84	70.95±1.17	69.13±1.47	15.93± .83	22.45±1.23	44.5	137.5	93.0
Non-cardiacs	49	64.59± .97	65.22±1.22	10.08± .69	15.61±1.09	33.8	88.0	54.2
Stature (cm.)								
Cardiacs	87	169.11± .50	168.71± .62	6.86± .35	4.06± .21	151.3	186.4	35.1
Non-cardiacs	50	170.50± .86	171.17±1.08	9.00± .61	5.28± .36	154.3	188.0	33.7
Height at ext. auditory meatus (cm.)								
Cardiacs	87	155.78± .52	155.87± .65	7.16± .37	4.60± .24	137.2	173.6	36.4
Non-cardiacs	50	157.10± .85	157.22±1.06	8.88± .60	5.65± .38	141.6	174.2	32.6
Height at suprasternal notch (cm.)								
Cardiacs	87	138.42± .44	138.34± .55	6.02± .31	4.35± .22	122.5	154.7	32.2
Non-cardiacs	50	139.60± .80	140.39±1.00	8.37± .56	5.99± .41	125.7	155.7	30.0
Height at lower costal margin (cm.)								
Cardiacs	83	109.49± .39	109.50± .49	5.29± .28	4.83± .25	94.8	123.2	28.4
Non-cardiacs	49	110.16± .63	110.63± .79	6.55± .45	5.95± .41	95.7	121.6	25.9
Height: sitting (cm.)								
Cardiacs	87	87.97± .26	88.24± .32	3.57± .18	4.06± .21	78.4	98.5	20.1
Non-cardiacs	50	88.10± .43	88.44± .54	4.54± .31	5.15± .35	78.5	98.0	19.5

Trunk length (cm.)								
Cardiacs	87	56.45± .25	56.88± .31	3.41± .18	6.05± .31	48.9	63.0	14.1
Non-cardiacs	47	56.09± .34	56.04± .43	3.48± .24	6.20± .43	49.1	64.3	15.2
Span (cm.)								
Cardiacs	86	174.65± .59	175.28± .74	8.13± .42	4.65± .24	155.2	195.5	40.3
Non-cardiacs	49	177.09± .97	178.33±1.22	10.09± .69	5.70± .39	157.2	199.5	42.3
Head length (cm.)								
Cardiacs	87	19.09± .07	19.11± .08	0.93± .05	4.88± .25	16.2	22.1	5.9
Non-cardiacs	50	18.88± .08	18.83± .10	0.83± .06	4.02± .27	17.3	20.1	2.8
Head breadth (cm.)								
Cardiacs	87	14.62± .06	14.65± .07	0.79± .04	5.38± .27	12.3	16.6	4.3
Non-cardiacs	50	14.64± .07	14.66± .09	0.76± .05	5.18± .35	12.2	16.1	3.9
Breadth—biacromial (cm.)								
Cardiacs	87	37.62± .22	38.36± .28	3.07± .16	8.17± .42	28.1	43.2	15.1
Non-cardiacs	50	36.76± .34	37.41± .43	3.59± .24	9.77± .67	25.8	43.0	17.2
Breadth—biiliac (cm.)								
Cardiacs	86	29.42± .13	29.26± .17	1.84± .10	6.27± .32	24.9	35.5	10.6
Non-cardiacs	49	28.55± .18	28.61± .23	1.88± .13	6.60± .45	22.6	35.5	12.9
Breadth—greatest hip (cm.)								
Cardiacs	86	33.84± .15	33.93± .19	2.04± .11	6.03± .31	29.2	40.2	11.0
Non-cardiacs	50	33.00± .21	33.00± .27	2.22± .15	6.74± .46	27.7	38.0	10.3
Chest depth (cm.)								
Cardiacs	87	21.80± .20	21.41± .25	2.78± .14	12.73± .66	17.4	28.4	11.0
Non-cardiacs	50	20.52± .14	20.54± .17	1.43± .10	6.97± .47	16.5	24.2	7.7
Girth—head (cm.)								
Cardiacs	87	56.52± .13	56.53± .16	1.76± .09	3.11± .16	53.0	61.5	8.5
Non-cardiacs	50	55.72± .13	54.82± .16	1.38± .09	2.47± .17	53.0	58.2	5.2

TABLE 2—*Continued*

CHARACTER	*N*	MEAN	MEDIAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MINIMUM OBS.	MAXIMUM OBS.	RANGE
Girth—neck (cm.)								
Cardiacs	84	37.21± .26	37.21± .33	3.59± .19	9.65± .48	29.0	50.1	21.1
Non-cardiacs	50	36.20± .20	36.13± .25	2.09± .14	5.77± .39	32.0	40.7	8.7
Girth—chest: expiration (cm.)								
Cardiacs	87	91.98± .66	91.14± .83	9.17± .47	9.97± .52	76.0	125.0	49.0
Non-cardiacs	50	88.30± .53	88.16± .66	5.53± .37	6.26± .42	73.6	98.0	24.4
Girth—chest: rest (cm.)								
Cardiacs	87	94.34± .68	93.06± .86	9.43± .48	9.99± .52	78.0	127.0	49.0
Non-cardiacs	50	90.30± .57	90.28± .72	6.01± .41	6.66± .45	74.0	104.0	30.0
Girth—chest: inspiration (cm.)								
Cardiacs	87	98.13± .68	96.95± .85	9.36± .48	9.53± .49	82.0	131.0	49.0
Non-cardiacs	50	94.90± .57	94.32± .71	5.95± .40	6.26± .42	77.5	108.0	30.5
Girth—umbilicus (cm.)								
Cardiacs	84	93.33±1.06	91.91±1.33	14.46± .75	15.49± .83	70.0	133.0	63.0
Non-cardiacs	48	87.10± .90	85.65±1.13	9.23± .64	10.59± .74	65.0	102.0	37.0
Ear length (cm.)								
Cardiacs	87	6.93± .04	6.96± .04	0.49± .03	7.01± .36	5.7	8.3	2.6
Non-cardiacs	50	6.77± .05	6.72± .06	0.54± .04	7.95± .54	5.9	8.1	2.2
Ear breadth (cm.)								
Cardiacs	87	3.34± .03	3.27± .03	0.38± .02	11.29± .58	2.3	4.4	2.1
Non-cardiacs	50	3.38± .04	3.53± .05	0.42± .03	12.56± .56	2.5	4.8	2.3

of weight of cardiacs over non-cardiacs, and being 4.1 times its probable error and therefore statistically significant. If we were to cut each of the individuals in the two groups into horizontal slices, each slice 10 cm. thick, the average weight of a slice of the cardiacs would be 4.20 kg. (9.26 lbs.), while the average non-cardiac slice would weigh but 3.79 kg. (8.36 lbs.), slightly less than a pound lighter.

3. The mean Span in the cardiac group is 2.44±1.14 cm. less than that in the non-cardiac group. This difference cannot be regarded as statistically significant, but it is in the same sense anthropometrically as the slight difference in stature between the two groups.

4. There is no significant difference in the means of the two groups in respect of (a) Head Length; (b) Head Breadth; (c) Biacromial Breadth; (d) Ear Length; or (e) Ear Breadth.

5. The mean dimension for the cardiac group is significantly, or very probably significantly, *greater* than that for the non-cardiac group in the case of the following variables: (a) Biiliac Breadth; (b) Greatest Hip Breadth; (c) Chest Depth; (d) Head Girth; (e) Neck Girth; (f) Chest Girth—Expiration; (g) Chest Girth—Rest; (h) Chest Girth—Inspiration; and (i) Girth at Umbilicus.

6. A comparison of the means and medians indicates that these two constants are not significantly different from each other for any one of the 44 distributions. From this it may be concluded that the distributions exhibit no asymmetry or skewness of any practical moment.

7. The *cardiacs* are relatively *more variable,* as a group, than the non-cardiacs by amounts that are statistically significant, or very probably so, when measured by the differences between coefficients of variation in relation to the probable errors of the differences, in respect of the following variables: Body Weight (4.2);[5] Chest Depth (7.1); Head Girth (2.8); Neck Girth (6.3); Chest Girth—Expiration (5.5); Chest Girth—Rest (4.8); Chest Girth—Inspiration (5.0); and Girth at Umbilicus (4.4). The cardiacs, as a group, are slightly but to a statistically insignificant degree more variable than the non-cardiacs in respect of Head Length (2.3) and Head Breadth (<1). The *non-cardiacs,* as a group, are relatively *more variable* than the cardiacs, by amounts that are statistically significant or very probably so, in respect of only two variables, namely Stature (2.9) and Height at Suprasternal Notch

[5] The figures in parentheses following each named variable in this paragraph are the values of the ratio, Difference/P.E. of difference.

(3.5). The non-cardiacs are insignificantly more variable than the cardiacs in respect of the following variables: Height at External Auditory Meatus (2.3); Height at Costal Margin (2.3); Sitting Height (2.7); Trunk Height (<1); Span (2.3); Biacromial Breadth (2.0); Biiliac Breadth (<1); Greatest Hip Breadth (1.3); Ear Length (1.4); Ear Breadth (1.6).

8. In 15 out of the 22 possible comparisons the *range* of observed variation leads qualitatively to the same conclusions as the coefficients of variation, so far as concerns the relatively greater or smaller variability of the cardiac or non-cardiac groups. In only two of the seven cases where comparison of the observed ranges fails to lead to the same conclusion as comparison of the coefficients of variation are the differences between the coefficients statistically significant or very probably so.

9. The three most variable characters of the 22 measured (as indicated by the coefficients of variation) are, in order, for both cardiacs and non-cardiacs Body Weight, Girth at Umbilicus, and Ear Breadth. The least variable character is Head Girth. This last is a character that comes close to being a "bone" measurement. On the other hand Body Weight and Girth at Umbilicus are markedly influenced by state of nutrition.

To sum up the results obtained from the direct anthropometric measurements we may say that the data present, in broad outline, the following picture: So far as the present samples are concerned the cardiacs and non-cardiacs, as groups, are of substantially the same stature, the non-cardiacs being slightly but not significantly taller. But the cardiacs are significantly heavier. This greater weight is a consequence primarily of greater girth at all levels of the body measured. This suggests that the cardiacs either tend more than the non-cardiacs to the pyknic habitus of body, or that they tend to be more obese (presumably chiefly in consequence of being more generally over-eaters), or both. As we proceed additional data will help towards a discrimination between these alternatives, but in the meantime the fact that the cardiacs are generally significantly more variable relatively in respect of just those characters of weight and girth in which they exhibit higher mean values, counts somewhat in favor of the alternative which ascribes the observed result to a tendency to obesity consequent upon systematic over-eating.

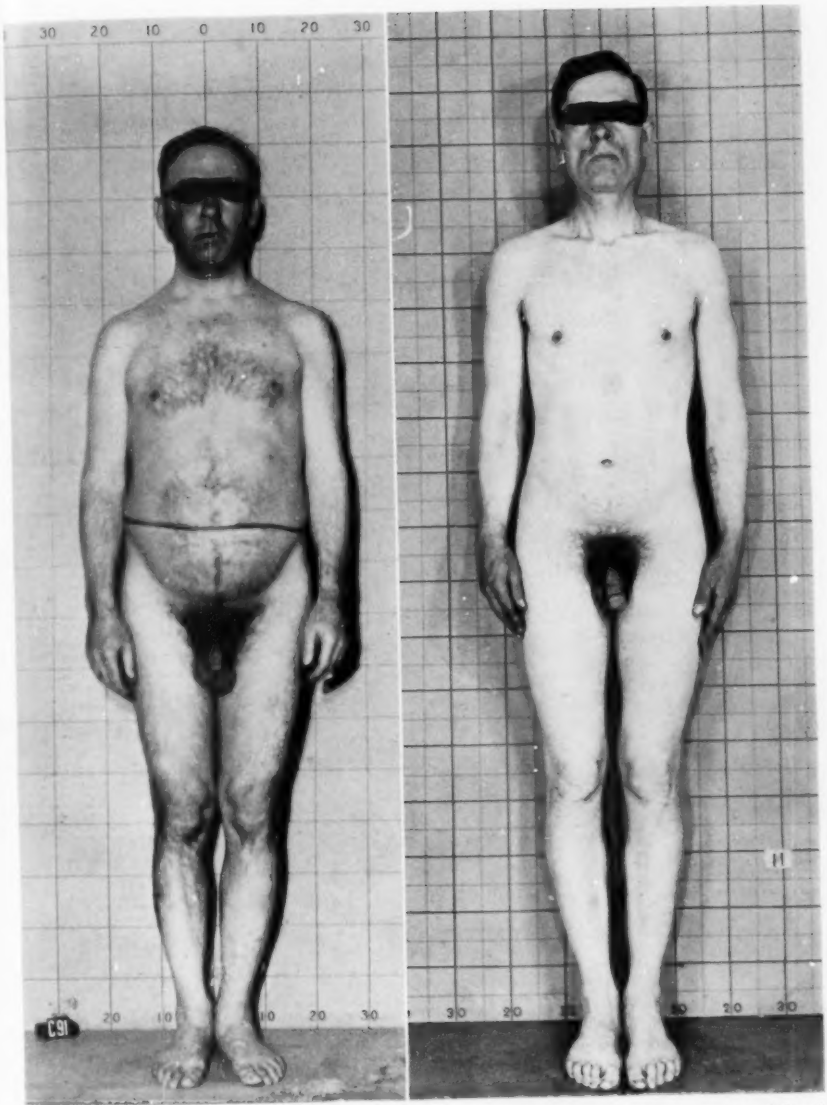

PLATE I. FRONT VIEW OF APPROXIMATELY "AVERAGE" CARDIAC INDIVIDUAL (C 91) IN PRESENT SAMPLE OF CARDIACS, AND OF APPROXIMATELY "AVERAGE" NON-CARDIAC INDIVIDUAL (A 46), PHOTO NO. 41) IN PRESENT SAMPLE OF NON-CARDIACS

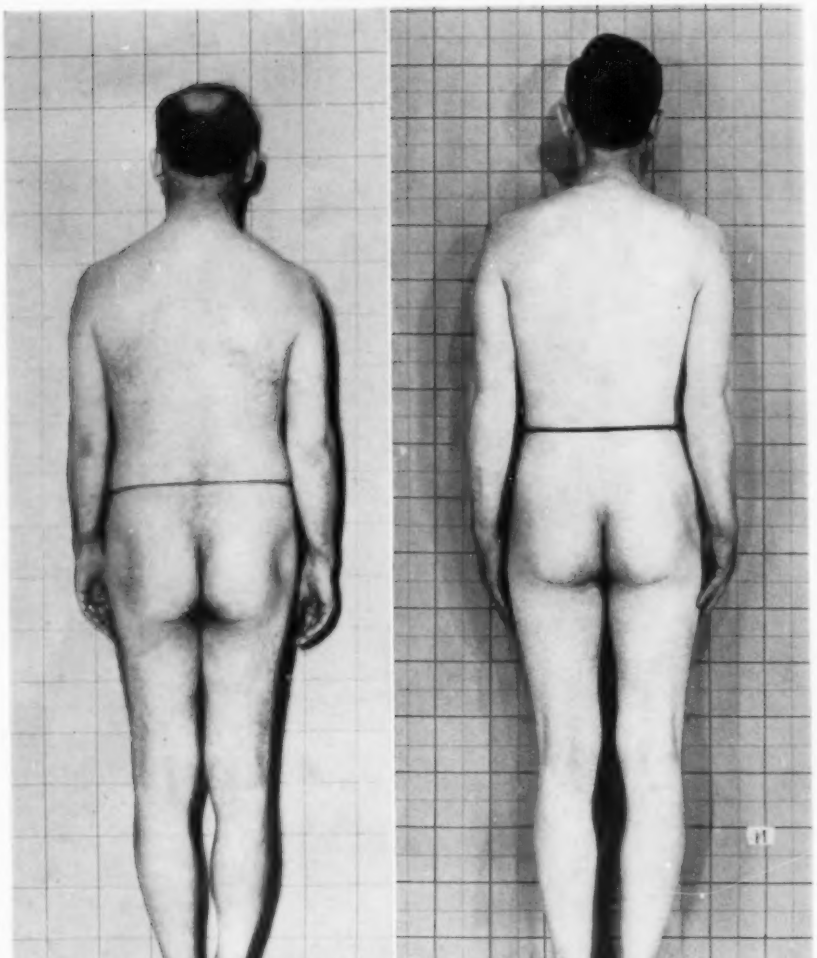

PLATE II. SAME AS PLATE I BUT REAR VIEW

In order to help towards an appreciation of the anthropometric differences between the cardiac and non-cardiac groups Table 3 and Plates I and II are presented. These concern two individuals, C 91 (a cardiac) and A 46 (a non-cardiac). These two individuals were selected for exhibition because each comes, on the whole, fairly close in his measurements to the mean of the group to which he belongs. In short, C 91 is sufficiently close to the "mean cardiac man" of our sample of cardiacs, and A 46 similarly may be looked upon as the "mean non-cardiac man" of our sample of non-cardiacs. Their respective measurements are given in Table 3.

TABLE 3

Comparison of Measurements of Approximately "Average" Cardiac (C 91) and Approximately "Average" Non-cardiac (A 46)

CHARACTER	CARDIAC (C 91)	NON-CARDIAC (A 46)
Age (years)	43	46
Body weight (kg.)	72.5	60
Stature (cm.)	168.7	170.6
Height at ext. auditory meatus (cm.)	155.4	157.1
Height at suprasternal notch (cm.)	138.1	139.1
Height at lower costal margin (cm.)	107.0	109.4
Height—sitting (cm.)	89.0	88.2
Height—trunk (cm.)	58.3	56.5
Span (cm.)	170.5	168.4
Head length (cm.)	20.5	18.0
Head breadth (cm.)	15.6	14.0
Breadth biacromial (cm.)	39.4	28.3
Breadth biiliac (cm.)	30.5	26.0
Breadth—greatest hip (cm.)	34.4	31.9
Chest depth (cm.)	18.0	18.2
Girth—head (cm.)	59.8	54.0
Girth—neck (cm.)	38.5	33.0
Girth—chest: expiration (cm.)	90.0	85.0
Girth—chest: rest (cm.)	93.0	89.0
Girth—chest: inspiration (cm.)	98.0	93.0
Girth at umbilicus (cm.)	96.0	75.0
Ear length (cm.)	6.9	6.0
Ear breadth (cm.)	3.0	3.4

While it is evident that the measurements of these two individuals do not, in respect of every single variable, show the same relationships as the means of Table 2, nevertheless they do, on the whole, give a fair general picture of the important somatic differentials between the two groups. The cardiac is shorter, heavier, and generally bigger around.

Plate I shows these two individuals in front view, and Plate II in back view.

COMPARISON OF DIRECT ANTHROPOMETRIC MEASUREMENTS IN DIFFERENT DISEASE GROUPS

A significant feature of constitutional somatology, as well as of physical anthropology generally, must always be intergroup comparison. In pathological matters within this field it is practically always impossible to get "controls," in the sense in which that word is used in experimental work. Comparisons then, of necessity, have to be made between pairs of groups differentiated from each other within broadly known limits.

In this section we shall exhibit such summarized comparisons as are possible, relative to direct somatic measurements, between our present groups and such other groups of American males with definite diseases as we have been able to collect from the literature. The number of these, especially in or near the age range of our groups, is not as great as we could wish. But exact quantitative studies of constitutional pathology are only in their infancy in this country. We have thought it best not to include foreign groups in the comparisons, because so many additional variables (racial, etc.) would be involved.

All of the comparison tables are arranged in the same manner, namely in descending order of the mean values for the different compared groups.

Body Weight, Stature, and Chest Girth

For reasons which will appear as we proceed it seems desirable to discuss body weight, stature, and chest girth, and certain derivative functions of these dimensions, together as a group. The data are presented in Tables 4-8 inclusive.

Tables 6 and 8 are derivative tables. Table 6 gives body weight ratio, one of the most useful of all figures in the discussion of body

TABLE 4

Mean Body Weight (in Kilograms) of Males With Various Diseases or Physical Defects

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN BODY WEIGHT (*kg.*)	*N*	AUTHORITY
1	U. S. Army officers with degenerative cardiovascular-renal disease 10 years after measurement	36-45	79.11± .78	108	Reed and Love (29) p. 77
2	U. S. Army officers with degenerative cardiovascular-renal disease 10 years after measurement	46-55	78.71± .77	100	Reed and Love (29) p. 78
3	U. S. Army officers with degenerative cardiovascular-renal disease at age measured	46-55	78.32± .74	118	Reed and Love (29) p. 78
4	U. S. Army officers with degenerative cardiovascular-renal disease at age measured or later.....	46-55	78.17± .52	235	Reed and Love (29) p. 78
5	U. S. Army officers with degenerative cardiovascular-renal disease 20 years after measurement	56-64	77.77±2.12	13	Reed and Love (29) p. 78
6	U. S. Army officers with degenerative cardiovascular-renal disease at age measured	36-45	77.77± .55	217	Reed and Love (29) p. 78
7	U. S. Army officers with degenerative cardiovascular-renal disease at age measured	56-64	77.12± .73	101	Reed and Love (29) p. 78

TABLE 4—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN BODY WEIGHT (*kg.*)	*N*	AUTHORITY
8	Old Americans. Lab. Series. No data as to disease	Above 59	76.93	10	Hrdlička (17) p. 102
9	U. S. Army officers with degenerative cardiovascular-renal disease at age measured or later.....	56-64	76.81± .64	144	Reed and Love (29) p. 78
10	Gall bladder disease	46.4	76.6	16	Draper (11) p. 334
11	U. S. Army officers with degenerative cardiovascular-renal disease at age measured	36-45	76.32±1.00	64	Reed and Love (29) p. 77
12	U. S. Army officers with degenerative cardiovascular-renal disease 20 years after measurement	36-45	75.79±1.26	45	Reed and Love (29) p. 78
13	U. S. Army officers with degenerative cardiovascular-renal disease 20 years after measurement	46-55	75.67±1.81	17	Reed and Love (29) p. 78
14	U. S. Army officers (random sample)	56-64	74.80± .26	720	Reed and Love (28) p. 512
15	U. S. Army officers (random sample)	46-55	74.40± .15	2,071	Reed and Love (28) p. 512
16	U. S. Army officers with valvular heart disease (other than aortic regurgitation) at age measured	56-64	74.03±1.51	10	Reed and Love (29) p. 71

TABLE 4—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN BODY WEIGHT (*kg.*)	*N*	AUTHORITY
17	U. S. Army officers with nervous or mental disease at age measured...	56-64	74.02±1.21	22	Reed and Love (29) p. 91
18	U. S. Army officers with degenerative cardiovascular-renal disease 10 years after measurement	56-64	73.83±1.35	30	Reed and Love (29) p. 78
19	U. S. Army officers with nervous or mental disease at age measured	46-55	73.49± .72	92	Reed and Love (29) p. 91
20	U. S. Army officers with nervous or mental disease at age measured or later	46-55	73.45± .65	117	Reed and Love (29) p. 91
21	U. S. Army officers with cancer at age measured or later	56-64	73.30±1.18	29	Reed and Love (29) p. 90
22	U. S. Army officers (random sample)	36-45	72.66± .12	3,232	Reed and Love (28) p. 512
23	Old Americans. Lab. Series. No data as to disease	50-59	72.48	32	Hrdlička (17) p. 102
24	U. S. Army officers with cancer at age measured or later	46-55	72.07± .91	53	Reed and Love (29) p. 90
25	U. S. Army officers with cancer at age measured..	46-55	71.70±1.31	28	Reed and Love (29) p. 90

TABLE 4—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN BODY WEIGHT (*kg.*)	*N*	AUTHORITY
26	U. S. Army officers with cancer at age measured or later	36-45	71.24±1.24	37	Reed and Love (29) p. 90
27	Old Americans. Lab. Series. No data as to disease	40-49	70.99	42	Hrdlička (17) p. 102
28	**Cardiacs**	**53.62±.50**	**70.95±1.17**	**84**	**This paper**
29	U. S. Army officers with valvular heart disease (other than aortic regurgitation) at age measured or later	36-45	70.85±1.06	36	Reed and Love (29) p. 71
30	U. S. Army officers with nervous or mental disease at age measured or later	36-45	70.74± .40	274	Reed and Love (29) p. 91
31	U. S. Army officers with nervous or mental disease at age measured	36-45	70.46± .46	192	Reed and Love (29) p. 91
32	U. S. Army officers with valvular heart disease (other than aortic regurgitation) at age measured	36-45	68.87±1.39	19	Reed and Love (29) p. 71
33	Normal, healthy males...	30.59±.21	68.75± .37	272	Pearl and Miner (25) p. 9
34	Arrested tuberculosis ...	32.44±.34	68.63± .83	50	Pearl and Miner (25) p. 22

TABLE 4—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN BODY WEIGHT (*kg.*)	*N*	AUTHORITY
35	Pernicious anemia	49.2	68.2	15	Draper (11) p. 334
36	U. S. Army officers with pulmonary tuberculosis at age measured or later...	46-55	67.77±1.37	22	Reed and Love (29) p. 68
37	Draft recruits with varicose veins	21-30	66.42	3,423	Davenport and Love(9) p. 349
38	U. S. Army officers with pulmonary tuberculosis at age measured or later...	36-45	65.67± .70	51	Reed and Love (29) p. 68
39	U. S. Army officers with pulmonary tuberculosis at age measured	36-45	65.53± .88	26	Reed and Love (29) p. 68
40	Draft recruits with flat foot	21-30	64.98	270,348	Davenport and Love(9) p. 371
41	**Non-cardiacs ..... .**	**49.80±.57**	**64.59± .97**	**49**	**This paper**
42	Draft recruits with simple goiter	21-30	64.57	7,099	Davenport and Love(9) p. 306
43	Tuberculosis	28.2	64.5	70	Draper (11) p. 334
44	Draft recruits with hypertrophic tonsillitis	21-30	64.31	52,031	Davenport and Love(9) p. 324
45	Draft recruits with varicocele	21-30	64.30	5,849	Davenport and Love(9) p. 351

TABLE 4—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN BODY WEIGHT (*kg.*)	*N*	AUTHORITY
46	Draft recruits with hernia	21-30	64.06	34,324	Davenport and Love(9) p. 366
47	Draft recruits with cardiac hypertrophy	21-30	63.73	1,343	Davenport and Love(9) p. 332
48	Draft recruits with hemorrhoids	21-30	63.68	1,824	Davenport and Love(9) p. 354
49	Draft recruits with genital defects	21-30	63.62	4,948	Davenport and Love(9) p. 380
50	Draft recruits with enlarged inguinal rings	21-30	63.54	43,619	Davenport and Love(9) p. 367
51	Draft recruits with myopia	21-30	63.15	2,420	Davenport and Love(9) p. 312
52	Draft recruits with astigmatism	21-30	63.12	1,592	Davenport and Love(9) p. 321
53	Draft recruits with asthma	21-30	63.05	1,581	Davenport and Love(9) p. 358
54	Draft recruits with mitral insufficiency	21-30	63.04	8,860	Davenport and Love(9) p. 336
55	Draft recruits with hyperopia	21-30	63.03	969	Davenport and Love(9) p. 316
56	Draft recruits with exophthalmic goiter	21-30	62.97	2,620	Davenport and Love(9) p. 310
57	Draft recruits with deficient teeth and caries..	21-30	62.74	17,983	Davenport and Love(9) p. 361

TABLE 4—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN BODY WEIGHT (*kg.*)	*N*	AUTHORITY
58	Active tuberculosis	31.49±.14	62.35± .27	449	Pearl and Miner (25) p. 22
59	Draft recruits with tachycardia	21-30	62.31	2,147	Davenport and Love(9) p. 328
60	Draft recruits with unspecified valvular disease	21-30	62.25	3,419	Davenport and Love(9) p. 343
61	Draft recruits with mitral stenosis	21-30	62.07	2,512	Davenport and Love(9) p. 340
62	Nephritis and hypertension	38.7	61.6	14	Draper (11) p. 334
63	Draft recruits with pulmonary tuberculosis	21-30	59.17	10,701	Davenport and Love(9) p. 302
64	Gastric and duodenal ulcer	36.2	58.7	24	Draper (11) p. 334
65	Draft recruits with defective physical development	21-30	56.93	1,292	Davenport and Love(9) p. 373
66	Draft recruits underweight	21-30	50.32	12,129	Davenport and Love(9) p. 377

TABLE 5

Mean Stature (in Centimeters) of Males With Various Diseases or Physical Defects

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN STATURE (*cm.*)	*N*	AUTHORITY
1	U. S. Army officers with valvular heart disease (other than aortic regurgitation) at age measured	36-45	177.52± .84	19	Reed and Love (29) p. 71
2	U. S. Army officers with valvular heart disease (other than aortic regurgitation) at age measured	56-64	176.78±1.07	10	Reed and Love (29) p. 71
3	U. S. Army officers with pulmonary tuberculosis at age measured or later...	36-45	176.76± .46	51	Reed and Love (29) p. 68
4	U. S. Army officers with pulmonary tuberculosis at age measured	36-45	176.53± .64	26	Reed and Love (29) p. 68
5	U. S. Army officers with pulmonary tuberculosis at age measured or later...	46-55	176.53± .74	22	Reed and Love (29) p. 68
6	U. S. Army officers with valvular heart disease (other than aortic regurgitation) at age measured or later	36-45	176.45± .61	36	Reed and Love (29) p. 71
7	U. S. Army officers with degenerative cardio-vascular-renal disease 20 years after measurement	56-64	175.84±1.17	13	Reed and Love (29) p. 78

TABLE 5—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN STATURE (*cm.*)	*N*	AUTHORITY
8	U. S. Army officers with degenerative cardiovascular-renal disease at age measured	36-45	175.82± .46	64	Reed and Love (29) p. 77
9	U. S. Army officers with degenerative cardio-vascular-renal disease at age measured	46-55	175.77± .38	118	Reed and Love (29) p. 78
10	U. S. Army officers with nervous or mental disease at age measured or later	46-55	175.72± .36	117	Reed and Love (29) p. 91
11	Arrested tuberculosis ...	32.44±.34	175.57± .64	50	Pearl and Miner (25) p. 22
12	U. S. Army officers with nervous or mental disease at age measured.....	46-55	175.57± .41	92	Reed and Love (29) p. 91
13	U. S. Army officers (random sample)	36-45	175.56± .07	3,232	Reed and Love (28) p. 511
14	U. S. Army officers (random sample)	46-55	175.39± .08	2,071	Reed and Love (28) p. 511
15	U. S. Army officers with nervous or mental disease at age measured.....	56-64	175.39± .64	22	Reed and Love (29) p. 91
16	U. S. Army officers with degenerative cardiovascular-renal disease 10 years after measurement	36-45	175.36± .41	108	Reed and Love (29) p. 77

TABLE 5—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN STATURE (*cm.*)	*N*	AUTHORITY
17	U. S. Army officers with nervous or mental disease at age measured or later	36-45	175.36± .23	274	Reed and Love (29) p. 91
18	U. S. Army officers with degenerative cardiovascular-renal disease at age measured or later.....	46-55	175.21± .25	235	Reed and Love (29) p. 78
19	U. S. Army officers with degenerative cardio-vascular-renal disease at age measured or later.....	36-45	175.11± .28	217	Reed and Love (29) p. 78
20	U. S. Army officers with degenerative cardiovascular-renal disease 10 years after measurement	46-55	174.88± .38	100	Reed and Love (29) p. 78
21	U. S. Army officers (random sample)	56-64	174.85± .14	720	Reed and Love (28) p. 511
22	U. S. Army officers with degenerative cardiovascular-renal disease 20 years after measurement	36-45	174.85± .56	45	Reed and Love (29) p. 78
23	U. S. Army officers with nervous or mental disease at age measured.....	36-45	174.85± .25	192	Reed and Love (29) p. 91
24	Old Americans. Lab. Series. No data as to disease	Above 59	174.78	12	Hrdlička (17) p. 80

TABLE 5—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN STATURE (*cm.*)	*N*	AUTHORITY
25	U. S. Army officers with degenerative cardiovascular-renal disease at age measured	56-64	174.63± .38	101	Reed and Love (29) p. 78
26	U. S. Army officers with cancer at age measured..	46-55	174.63± .64	28	Reed and Love (29) p. 90
27	Old Americans. Lab. Series. No data as to disease	40-49	174.54	47	Hrdlička (17) p. 80
28	U. S. Army officers with cancer at age measured or later	36-45	174.45± .58	37	Reed and Love (29) p. 90
29	U. S. Army officers with cancer at age measured or later	46-55	174.40± .51	53	Reed and Love (29) p. 90
30	U. S. Army officers with cancer at age measured or later	56-64	174.40± .74	29	Reed and Love (29) p. 90
31	U. S. Army officers with degenerative cardiovascular-renal disease at age measured or later.....	56-64	174.22± .33	144	Reed and Love (29) p. 78
32	Old Americans. Lab. Series. No data as to disease	50-59	173.98	34	Hrdlička (17) p. 80
33	Active tuberculosis	31.49±.14	173.96± .20	449	Pearl and Miner (25) p. 22

TABLE 5—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN STATURE (*cm.*)	*N*	AUTHORITY
34	Draft recruits with varicose veins	21-30	173.81	3,423	Davenport and Love(9) p. 349
35	U. S. Army officers with degenerative cardiovascular-renal disease 20 years after measurement	46-55	173.76± .69	17	Reed and Love (29) p. 78
36	Draft recruits with varicocele	21-30	173.66	5,849	Davenport and Love(9) p. 351
37	Tuberculosis	28.2	173.38	75	Draper (11) p. 334
38	Pernicious anemia	49.2	173.10	19	Draper (11) p. 334
39	Normal, healthy males..	30.59±.21	173.05± .25	272	Pearl and Miner (25) p. 9
40	Draft recruits with pulmonary tuberculosis	21-30	172.90	10,701	Davenport and Love(9) p. 302
41	Draft recruits with exophthalmic goiter	21-30	172.64	2,620	Davenport and Love(9) p. 310
42	Draft recruits with simple goiter	21-30	172.57	7,099	Davenport and Love(9) p. 306
43	Draft recruits with mitral insufficiency	21-30	172.31	8,860	Davenport and Love(9) p. 336
44	Draft recruits with hemorrhoids	21-30	172.21	1,824	Davenport and Love(9) p. 354

TABLE 5—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN STATURE (*cm.*)	*N*	AUTHORITY
45	Draft recruits with tachycardia	21-30	172.11	2,147	Davenport and Love(9) p. 328
46	Draft recruits with cardiac hypertrophy	21-30	172.09	1,343	Davenport and Love(9) p. 332
47	U. S. Army officers with degenerative cardiovascular-renal disease 10 years after measurement	56-64	172.06± .66	30	Reed and Love (29) p. 78
48	Draft recruits with mitral stenosis	21-30	171.78	2,512	Davenport and Love(9) p. 340
49	Draft recruits with unspecified valvular disease	21-30	171.70	3,419	Davenport and Love(9) p. 343
50	Draft recruits with hypertrophic tonsillitis	21-30	171.39	52,031	Davenport and Love(9) p. 324
51	Draft recruits with enlarged inguinal rings	21-30	171.35	43,619	Davenport and Love(9) p. 367
52	Draft recruits with hernia	21-30	171.30	34,220	Davenport and Love(9) p. 365
53	Draft recruits with genital defects	21-30	171.30	4,948	Davenport and Love(9) p. 380
54	Draft recruits with flat foot	21-30	170.94	270,348	Davenport and Love(9) p. 371
55	Draft recruits with deficient teeth and caries	21-30	170.84	17,983	Davenport and Love(9) p. 361

TABLE 5—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN STATURE (*cm.*)	*N*	AUTHORITY
56	Gall bladder disease.....	46.4	170.79	17	Draper (11) p. 334
57	Draft recruits with asthma	21-30	170.79	1,581	Davenport and Love(9) p. 358
58	**Non-cardiacs	**49.80±.57**	**170.50± .86**	**50**	**This paper**
59	Draft recruits with myopia	21-30	170.38	2,420	Davenport and Love(9) p. 312
60	Draft recruits with hyperopia	21-30	170.38	969	Davenport and Love(9) p. 316
61	Draft recruits with astigmatism	21-30	170.36	1,592	Davenport and Love(9) p. 321
62	**Cardiacs	**53.62±.50**	**169.11± .50**	**87**	**This paper**
63	Draft recruits with defective physical development	21-30	169.09	1,292	Davenport and Love(9) p. 373
64	Nephritis and hypertension	38.7	167.86	15	Draper (11) p. 334
65	Draft recruits underweight	21-30	166.37	12,129	Davenport and Love(9) p. 377
66	Gastric and duodenal ulcer	36.2	164.28	30	Draper (11) p. 334

TABLE 6

Mean Body Weight Ratio (Kilograms per 10 cm. of Stature) of Males With Various Diseases or Physical Defects

(Computed from the means of Tables 4 and 5)

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN NUMBER OF KILOGRAMS PER 10 CM. OF STATURE
1	U. S. Army officers with degenerative cardiovascular-renal disease 10 years after measurement...	36-45	4.51
2	U. S. Army officers with degenerative cardiovascular-renal disease 10 years after measurement....	46-55	4.50
3	Gall bladder disease.....	46.4	4.49
4	U. S. Army officers with degenerative cardiovascular-renal disease at age measured.....	46-55	4.46
5	U. S. Army officers with degenerative cardiovascular-renal disease at age measured or later.....	46-55	4.46
6	U. S. Army officers with degenerative cardiovascular-renal disease at age measured or later.....	36-45	4.44
7	U. S. Army officers with degenerative cardiovascular-renal disease at age measured.....	56-64	4.42
8	U. S. Army officers with degenerative cardiovascular-renal disease 20 years after measurement...	56-64	4.42
9	U. S. Army officers with degenerative cardiovascular-renal disease at age measured or later.....	56-64	4.41
10	Old Americans. Lab. Series. No data as to disease	Above 59	4.40
11	U. S. Army officers with degenerative cardiovascular-renal disease 20 years after measurement...	46-55	4.35
12	U. S. Army officers with degenerative cardiovascular-renal disease at age measured.....	36-45	4.34
13	U. S. Army officers with degenerative cardiovascular-renal disease 20 years after measurement...	36-45	4.33

TABLE 6—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN NUMBER OF KILOGRAMS PER 10 CM. OF STATURE
14	U. S. Army officers with degenerative cardiovascular-renal disease 10 years after measurement...	56-64	4.29
15	U. S. Army officers (random sample).....	56-64	4.28
16	U. S. Army officers (random sample).....	46-55	4.24
17	U. S. Army officers with nervous or mental disease at age measured.....	56-64	4.22
18	**Cardiacs**	**53.62±.50**	**4.20**
19	U. S. Army officers with valvular heart disease (other than aortic regurgitation) at age measured	56-64	4.20
20	U. S. Army officers with cancer at age measured or later	56-64	4.20
21	U. S. Army officers with nervous or mental disease at age measured.....	46-55	4.19
22	U. S. Army officers with nervous or mental disease at age measured or later.....	46-55	4.18
23	Old Americans. Lab. Series. No data as to disease	50-59	4.17
24	U. S. Army officers (random sample).....	36-45	4.14
25	U. S. Army officers with cancer at age measured or later	46-55	4.13
26	U. S. Army officers with cancer at age measured	46-55	4.11
27	U. S. Army officers with cancer at age measured or later	36-45	4.08
28	Old Americans. Lab. Series. No data as to disease	40-49	4.07
29	U. S. Army officers with nervous or mental disease at age measured.....	36-45	4.03

TABLE 6—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN NUMBER OF KILOGRAMS PER 10 CM. OF STATURE
30	U. S. Army officers with nervous or mental disease at age measured or later	36-45	4.03
31	U. S. Army officers with valvular heart disease (other than aortic regurgitation) at age measured or later	36-45	4.02
32	Normal healthy males	30.59±.21	3.97
33	Pernicious anemia	49.2	3.94
34	Arrested tuberculosis	32.44±.34	3.91
35	U. S. Army officers with valvular heart disease (other than aortic regurgitation) at age measured	36-45	3.88
36	U. S. Army officers with pulmonary tuberculosis at age measured or later	46-55	3.84
37	Draft recruits with varicose veins	21-30	3.82
38	Draft recruits with flat foot	21-30	3.80
39	**Non-cardiacs**	**49.80±.57**	**3.79**
40	Draft recruits with hypertrophic tonsillitis	21-30	3.75
41	Draft recruits with simple goiter	21-30	3.74
42	Draft recruits with hernia	21-30	3.74
43	Tuberculosis (Draper's series)	28.2	3.72
44	U. S. Army officers with pulmonary tuberculosis at age measured or later	36-45	3.72
45	Draft recruits with myopia	21-30	3.71
46	Draft recruits with astigmatism	21-30	3.71

TABLE 6—*Continued*

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	MEAN NUMBER OF KILOGRAMS PER 10 CM. OF STATURE
47	Draft recruits with enlarged inguinal rings.....	21-30	3.71
48	Draft recruits with genital defects.....	21-30	3.71
49	U. S. Army officers with pulmonary tuberculosis at age measured	36-45	3.71
50	Draft recruits with hyperopia	21-30	3.70
51	Draft recruits with cardiac hypertrophy.....	21-30	3.70
52	Draft recruits with varicocele.....	21-30	3.70
53	Draft recruits with hemorrhoids.....	21-30	3.70
54	Draft recruits with asthma	21-30	3.69
55	Nephritis and hypertension	38.7	3.67
56	Draft recruits with deficient teeth and caries.....	21-30	3.67
57	Draft recruits with mitral insufficiency.....	21-30	3.66
58	Draft recruits with exophthalmic goiter.....	21-30	3.65
59	Draft recruits with unspecified valvular disease..	21-30	3.63
60	Draft recruits with tachycardia.....	21-30	3.62
61	Draft recruits with mitral stenosis.....	21-30	3.61
62	Active tuberculosis	31.49±.14	3.58
63	Gastric and duodenal ulcer.....	36.2	3.57
64	Draft recruits with pulmonary tuberculosis	21-30	3.42
65	Draft recruits with defective physical development	21-30	3.37
66	Draft recruits underweight	21-30	3.02

TABLE 7

Mean Chest Circumference at Expiration (in Centimeters) of Males With Various Diseases or Physical Defects

(Age data omitted because same as in Table 4 for same groups)

ORDER	GROUP	MEAN CHEST CIRCUMFERENCE AT EXPIRATION * (*cm.*)	*N*	AUTHORITY
1	Gall bladder disease.....	96.29	16	Draper (11) p. 335
2	**Cardiacs ..... .**	**91.98±.66**	**87**	**This paper**
3	Pernicious anemia	91.58	16	Draper (11) p. 335
4	U. S. Army officers.....	91.24±1.63	716	Reed and Love (28) p. 515
5	U. S. Army officers.....	90.45±.09	2,066	Reed and Love (28) p. 515
6	Tuberculosis	89.21	75	Draper (11) p. 335
7	U. S. Army officers.....	88.87±.07	3,230	Reed and Love (28) p. 515
8	**Non-cardiacs ..... .**	**88.30±.53**	**50**	**This paper**
9	Nephritis and hypertension	87.73	15	Draper (11) p. 335
10	Gastric and duodenal ulcer	87.60	30	Draper (11) p. 335
11	Draft recruits with varicose veins	85.52	3,426	Davenport and Love (9) p. 350
12	Draft recruits with asthma	84.68	1,579	Davenport and Love (9) p. 359
13	Draft recruits with hypertrophic tonsillitis	84.28	51,985	Davenport and Love (9) p. 325
14	Draft recruits with simple goiter	84.10	7,085	Davenport and Love (9) p. 307
15	Draft recruits with hernia	84.10	34,220	Davenport and Love (9) p. 365
16	Draft recruits with hemorrhoids	84.07	1,819	Davenport and Love (9) p. 355
17	Draft recruits with varicocele	83.97	5,836	Davenport and Love (9) p. 352

TABLE 7—*Continued*

ORDER	GROUP	MEAN CHEST CIRCUMFERENCE AT EXPIRATION * (*cm.*)	*N*	AUTHORITY
18	Draft recruits with enlarged inguinal rings.....	83.97	43,625	Davenport and Love (9) p. 368
19	Draft recruits with hyperopia	83.95	968	Davenport and Love (9) p. 317
20	Draft recruits with astigmatism	83.90	1,587	Davenport and Love (9) p. 322
21	Draft recruits with genital defects	83.90	4,943	Davenport and Love (9) p. 381
22	Draft recruits with deficient teeth and caries	83.82	17,932	Davenport and Love (9) p. 362
23	Draft recruits with myopia	83.74	2,417	Davenport and Love (9) p. 313
24	Draft recruits with cardiac hypertrophy	83.74	1,339	Davenport and Love (9) p. 333
25	Draft recruits with exophthalmic goiter	83.44	2,622	Davenport and Love (9) p. 311
26	Draft recruits with tachycardia	83.34	2,143	Davenport and Love (9) p. 329
27	Draft recruits with mitral insufficiency	83.19	8,830	Davenport and Love (9) p. 337
28	Draft recruits with mitral stenosis	82.93	2,507	Davenport and Love (9) p. 341
29	Draft recruits with unspecified valvular disease	82.70	3,406	Davenport and Love (9) p. 344
30	Draft recruits with pulmonary tuberculosis	81.51	10,649	Davenport and Love (9) p. 303
31	Draft recruits with defective physical development..	80.90	1,284	Davenport and Love (9) p. 374
32	Draft recruits underweight	77.37	12,132	Davenport and Love (9) p. 378

* Mean circumference in the case of the Draper data.

TABLE 8

Computed Cylindrical Body Volume (in c. c.) of Males With Various Diseases or Physical Defects

(Calculated from data of Tables 5 and 7)

ORDER	GROUP	MEAN AGE OR AGE LIMITS (*yrs.*)	COMPUTED CYLINDRICAL BODY VOL. (*c. c.*)
1	U. S. Army officers (random sample)	56-64	115,831
2	U. S. Army officers (random sample)	46-55	114,186
3	**Cardiacs (this paper)**	**53.62±.50**	**113,853**
4	U. S. Army officers (random sample)	36-45	110,338
5	**Non-cardiacs (this paper)**	**49.80±.57**	**105,788**
6	Draft recruits with varicose veins	21-30	101,158
7	Draft recruits with asthma	21-30	97,457
8	Draft recruits with varicocele	21-30	97,440
9	Draft recruits with simple goiter	21-30	97,129
10	Draft recruits with hypertrophic tonsillitis	21-30	96,878
11	Draft recruits with hemorrhoids	21-30	96,857
12	Draft recruits with hernia	21-30	96,414
13	Draft recruits with enlarged inguinal rings	21-30	96,144
14	Draft recruits with cardiac hypertrophy	21-30	96,031
15	Draft recruits with genital defects	21-30	95,956
16	Draft recruits with exophthalmic goiter	21-30	95,649
17	Draft recruits with hyperopia	21-30	95,554
18	Draft recruits with deficient teeth and caries	21-30	95,516
19	Draft recruits with astigmatism	21-30	95,429
20	Draft recruits with tachycardia	21-30	95,127
21	Draft recruits with myopia	21-30	95,077
22	Draft recruits with mitral insufficiency	21-30	94,895
23	Draft recruits with mitral stenosis	21-30	94,013
24	Draft recruits with unspecified valvular lesions	21-30	93,448
25	Draft recruits with pulmonary tuberculosis	21-30	91,413
26	Draft recruits with deficient physical development	21-30	88,065
27	Draft recruits underweight	21-30	79,252

build. The values in it are computed from the means of Tables 4 and 5 according to the following formula:

$$\frac{10 \times \text{mean body weight in kg.}}{\text{Mean stature in cm.}}$$

The resulting figures give the number of kilograms of body weight for each 10 cm. of stature, on the average.

Table 8 gives a new anthropometric index, mean computed cylindrical body volume. The values are computed from the following formula:

$$\text{Mean computed cylindrical body volume} = .079577\ (\text{Chest girth in cm.})^2 \times \text{Stature in cm.}$$

This gives the volume of a cylinder having its height equal to the observed stature and its circumference equal to the observed chest girth. The formula is derived as follows, letting V denote the volume of a cylinder, r its radius, h its height, and c its circumference,

$$V = \pi r^2 h$$

$$= \pi \left(\frac{c}{2\pi}\right)^2 h$$

$$= \frac{c^2 h}{4\pi}$$

$$\frac{1}{4\pi} = .07957747$$

The results will be in cubic centimeters, and will express the volume of a cylinder of the same height as the observed man, having a circumference equal to his chest girth. If one were to construct such a cylinder out of tin, let us say, for a particular man, then cut off the man's arms by straight vertical cuts upwards from the axillae parallel to the sagittal plane, and then pack the arms neatly fore and aft between the legs, and knead the trunk to a circular cross-sectional outline, the man would then fairly closely fit the cylinder, with relatively no great amount of unoccupied space.

From Tables 4-8 inclusive the following general picture emerges.

Our cardiac group is relatively short and heavy as compared with Pearl and Miner's group of normal, healthy males taken at random from the general population. Especially are they relatively short. The cardiacs stand 62nd in Stature among the 66 compared groups, and the

non-cardiacs 58th. This means that, by and large, the cardiacs are a group of relatively small people, in terms of skeletal size. Relatively heavy as they are (standing 18th among the 66 groups in mean weight per 10 cm. of stature) they are only 28th in rank in absolute body weight, averaging almost 9 kg. lighter than the first group in Table 4. But, because of their large girths they have a much larger mean computed cylindrical body volume (Table 8) than younger people.

On the other hand Reed and Love's Army Officer groups are composed of individuals initially *selected* in some part for bodily size, and in particular for soundness and vigor of general physical development. As a class they are physically larger men than either our or Draper's hospital groups or than Pearl and Miner's group of normal, healthy males. They average from 5 to 8 cm. taller than our cardiac group and, at comparable ages, are only slightly smaller in chest girth. Naturally under these circumstances these Army officers weigh more, on the average, and have a computed cylindrical body volume (Table 8) from roughly 300 to 2000 cc. greater.

These facts mean that our hospital groups cannot fairly be compared directly with the Army Officer groups, in respect of absolute somatic dimensions, without certain definite reservations consequent upon the highly selected character of the officer samples.

Similarly the draft recruit groups of Davenport and Love are not fairly comparable with our hospital samples. Here there are two reasons. The first and most important is age. The recruits are young men, many of whom in fact had probably not entirely completed their somatic growth. In the second place they were again, for the most part, selected relative to stature. But it is the consequences of their youth that chiefly characterize them physically. They have not lived long enough to "fill out."

As we study the tables it clearly appears that cardiac and vascular disease, especially with advancing age, tends to have associated with it high body weight, both absolute and relative. Of the 17 groups standing first in order of body weight ratio (Table 6) 12 are characterized by degenerative cardiovascular-renal disease. The other five groups include Draper's gall-bladder disease sample, obviously a greatly over-weight group, Hrdlička's Old American group over 59 years of age, about whose pathology there is no record, Army officers with nervous or mental disease, 56-64 years of age, and the two random samples of Army officers of ages over 46 years. Throughout we see the effect of

advancing age in increasing mean body weight. This increase is not a constitutional change in the usual sense of the words. Common observation and common sense agree in the conclusion that it is mainly a taking on of fat due to lessened physical activity and relative overeating. That this weight excess is etiologically connected with the production of heart disease in middle and later life has yet to be completely and definitely proved, but a study of the data arrayed in Tables 4-8 suggests such a possibility, and, indeed, even probability.

The difference between the group in Table 4 showing the greatest mean body weight and that showing the lowest mean body weight is 57.2 per cent of the latter. This is a large relative difference. In respect of stature (Table 5) the corresponding difference is but 8.1 per cent. The contrast between these two percentages is great. It reflects clearly the fact that stature is a much more stable constitutional character than body weight. After growth is completed stature is but little affected by environmental circumstances, whereas body weight is influenced by disease, by nutritional habits, etc. Coming to body weight ratio (Table 6) we find that the difference between the best-fleshed and the worst-fleshed groups is 49.3 per cent of the mean value for the latter. The predominant influence of body weight in determining the value of this ratio is apparent. In respect of chest girth (Table 7) there is a difference between the first group and the last group in the table amounting

TABLE 9

Mean Sitting Height (in Centimeters) of Males With Various Diseases

ORDER	GROUP	MEAN AGE (*yrs.*)	MEAN SITTING HEIGHT (*cm.*)	*N*	AUTHORITY
1	Tuberculosis	28.2	89.52	75	Draper (11) p. 334
2	Pernicious anemia	49.2	89.03	18	Draper (11) p. 334
3	Gall bladder disease.....	46.4	88.25	16	Draper (11) p. 334
4	**Non-cardiacs	**49.80±.57**	**88.10±.43**	**50**	**This paper**
5	**Cardiacs	**53.62±.50**	**87.97±.26**	**87**	**This paper**
6	Gastric and duodenal ulcer	36.2	87.92	30	Draper (11) p. 334
7	Nephritis and hypertension	38.7	87.47	15	Draper (11) p. 334

to 24.5 per cent of the mean value of the latter. Here again the effects of nutritional status and specific diseases are apparent. The difference between the groups with respectively greatest and least mean computed cylindrical body volume (Table 8) is 46.2 per cent of the mean value exhibited by the latter group.

While space is lacking for a further detailed discussion of these long Tables 4-8, it is hoped that they will be found useful for reference by anthropologists and medical men.

Sitting Height

For Sitting Height, and the other dimensions now to be compared, there are available for American male disease groups only Draper's (11) data and those of the present paper. Table 9 gives the data for Sitting Height.

Among the seven groups the tuberculous, as would be expected, show the highest mean Sitting Height, and the nephritics the lowest, but there is only a half centimeter difference between these and our cardiac group. As would be expected the groups order themselves relative to Sitting Height as they do for total height (Table 5) except that the last two groups in Table 9 reverse the order in which they stand relative to stature. This would suggest that the nephritics were longer-legged than the ulcer group, on the average, but actually Draper's figures (*loc. cit.* p. 335) indicate a slightly greater mean "Lower extremity length" in the ulcer group. Whether this apparent discrepancy is connected with different degrees of fleshing in the two groups is not clear.

The difference between the group in Table 9 showing the greatest mean Sitting Height and the group showing the smallest mean amounts to but 2.3 per cent of the latter mean. This again demonstrates the relative stability of height dimensions.

Trunk Length

The data are given in Table 10.

The greatest mean Trunk Length is in the nephritic group and the smallest in the non-cardiacs. Having regard to the Stature and Sitting Height data already presented the position of our cardiac and non-cardiac groups relative to Trunk Length is not inconsistent. But it is somewhat difficult to understand the arrangement of Draper's groups in Table 10, having regard to Table 9 and the Stature data.

TABLE 10

Mean Trunk Length (in Centimeters) of Males With Various Diseases

(Age data same as in Table 9)

ORDER	GROUP	MEAN TRUNK LENGTH (*cm.*)	*N*	AUTHORITY
1	Nephritis and hypertension	57.86	15	Draper (11) p. 335
2	Gall bladder disease.....	57.50	17	Draper (11) p. 335
3	Pernicious anemia	57.36	18	Draper (11) p. 335
4	Tuberculosis	56.82	75	Draper (11) p. 335
5	Gastric and duodenal ulcer	56.61	30	Draper (11) p. 335
6	**Cardiacs**	**56.45±.25**	**87**	**This paper**
7	**Non-cardiacs**	**56.09±.34**	**47**	**This paper**

The difference between the first and last groups of Table 10 in mean Trunk Length is 3.2 per cent of the smallest mean. Here, just as in the case of Sitting Height, the difference is too small to be apparent without precise measurement.

Span

The data are presented in Table 11.

TABLE 11

Mean Span (in Centimeters) of Males With Various Diseases

(Age data same as in Table 9, and references same as in Table 10)

ORDER	GROUP	MEAN SPAN (*cm.*)	*N*
1	Pernicious anemia	177.16	19
2	**Non-cardiacs**	**177.09±.97**	**49**
3	Gall bladder disease	175.93	16
4	Tuberculosis	175.43	75
5	**Cardiacs**	**174.65±.59**	**86**
6	Gastric and duodenal ulcer.....	172.95	28
7	Nephritis and hypertension	171.49	14

As would be expected from the high correlation between Span and Stature the seven groups of Table 11 arrange themselves in an order not widely different for that relative to Stature. But there are some puzzling discrepancies in Draper's material, especially as regards the tuberculosis and gall bladder disease groups.

The difference between the group with the greatest mean Span in Table 11 and the group with the smallest mean is 3.3 per cent of the latter mean. The corresponding difference relative to Stature, for the same seven groups, is 5.5 per cent of the mean for the group with the lowest Stature (gastric and duodenal ulcer), the group with the highest mean Stature being the tuberculous. It is interesting and somewhat unexpected that Span should exhibit a lower relative range of inter-group variability than the anthropometrically extremely stable character Stature.

Head Dimensions

The data for Head Length, Head Breadth, and Head Girth are given in Table 12, 13 and 14 respectively.

Taking the three head dimensions into account together it appears that, on the whole, the gall bladder disease group has the largest heads, among the seven groups compared. Our non-cardiac group has, on the

TABLE 12

Mean Head Length (in Centimeters) of Males With Various Diseases

(Age data and references same as in Table 9)

ORDER	GROUP	MEAN HEAD LENGTH (*cm.*)	*N*
1	Tuberculosis	19.39	75
2	Gall bladder disease	19.38	17
3	Gastric and duodenal ulcer	19.16	30
4	Nephritis and hypertension	19.15	18
5	**Cardiacs**	**19.09±.07**	**87**
6	Pernicious anemia	18.98	21
7	**Non-cardiacs**	**18.88±.08**	**50**

TABLE 13

Mean Head Breadth (in Centimeters) of Males With Various Diseases

(Age data and references same as in Table 9)

ORDER	GROUP	MEAN HEAD BREADTH (*cm.*)	*N*
1	Gall bladder disease	15.67	17
2	Pernicious anemia	15.65	21
3	Gastric and duodenal ulcer	15.19	30
4	Tuberculosis	15.18	75
5	Nephritis and hypertension	14.99	18
6	**Non-cardiacs**	**14.64±.07**	**50**
7	**Cardiacs**	**14.62±.06**	**87**

TABLE 14

Mean Head Girth (in Centimeters) of Males With Various Diseases

(Age data and references same as in Table 9)

ORDER	GROUP	MEAN HEAD GIRTH (*cm.*)	*N*
1	Nephritis and hypertension	57.31	1
2	Gall bladder disease	56.82	17
3	**Cardiacs**	**56.52±.13**	**87**
4	Tuberculosis	56.28	74
5	Gastric and duodenal ulcer	56.28	10
6	**Non-cardiacs**	**55.72±.13**	**50**

whole, the smallest heads. The cephalic indices of the groups will be discussed later.

The difference in Head Length between groups No. 1 and No. 7 of Table 12 is 2.7 per cent of the mean for the latter group. The corresponding difference for Head Breadth from Table 13 is 7.2 per cent of the mean of the group (Cardiacs) showing the smallest mean. For Head Circumference (Table 14) the corresponding percentage

difference is 2.9 per cent. But it must be noted that Table 14 (Head Girth) contains only six instead of seven groups, and that the first line in the table (nephritis and hypertension) concerns not a group, but a single individual. The greater relative intergroup range in Head Breadth as compared with Head Length may possibly reflect the fact that the former dimension is more difficult to measure uniformly and accurately than the latter.

Biacromial and Biiliac Breadths

Tables 15 and 16 respectively present the data.

TABLE 15

Mean Biacromial Breadth (in Centimeters) of Males With Various Diseases

(Age data same as in Table 9, and references same as in Table 10)

ORDER	GROUP	MEAN BIACROMIAL BREADTH (*cm.*)	*N*
1	Gall bladder disease	38.52	17
2	Pernicious anemia	38.40	19
3	Tuberculosis	38.26	75
4	Gastric and duodenal ulcer	37.75	30
5	**Cardiacs**	**37.62±.22**	**87**
6	Nephritis and hypertension	37.39	15
7	**Non-cardiacs**	**36.76±.34**	**50**

TABLE 16

Mean Biiliac Breadth (in Centimeters) of Males With Various Diseases

(Age data same as in Table 9, and references same as in Table 10)

ORDER	GROUP	MEAN BIILIAC BREADTH (*cm.*)	*N*
1	Gall bladder disease	29.95	17
2	Pernicious anemia	29.42	19
3	**Cardiacs**	**29.42±.13**	**86**
4	Gastric and duodenal ulcer	28.60	30
5	**Non-cardiacs**	**28.55±.18**	**49**
6	Tuberculosis	28.43	75
7	Nephritis and hypertension	28.19	15

A study of the data indicates that the gall bladder disease, pernicious anemia, and cardiac groups are the "well-fleshed" groups. As a matter of fact it is probable that in each of these cases the individuals were, on the average, over-fat. Their body breadths order themselves as they do probably more because of this factor than because of skeletal build. On the other hand the emaciating effects of the disease itself seem apparent in the case of tuberculosis and nephritis.

The relative differences in mean Biacromial and Biiliac Breadths between the groups in Table 15 and 16 with respectively highest and lowest means are 4.8 per cent of the lowest biacromial group mean, and 6.2 per cent of the lowest biiliac group mean. Shoulder breadth then appears to be a more conservative character than hip breadth in inter-group comparison, although as seen in Table 2 the opposite is true in respect of relative inter-individual variation.

Chest Depth

The data are given in Table 17.

TABLE 17

Mean Chest Depth (in Centimeters) of Males With Various Diseases

(Age data same as in Table 9, and references same as in Table 10)

ORDER	GROUP	MEAN CHEST DEPTH (*cm.*)	*N*
1	Gall bladder disease	23.14	16
2	Pernicious anemia	22.69	19
3	**Cardiacs**	**21.80±.20**	**87**
4	Nephritis and hypertension	21.35	15
5	Gastric and duodenal ulcer	20.66	30
6	**Non-cardiacs**	**20.52±.14**	**50**
7	Tuberculosis	20.15	74

As would be expected the measurements of Table 17 clearly reflect the "hollow-chestedness" of the tuberculous. The gall bladder disease and pernicious anemia groups order themselves relative to chest depth as they do relative to the body breadths discussed in the preceding section, and insofar support the conclusion there reached. The differ-

ence between the groups with respectively the greatest mean chest depth and the smallest mean chest depth is 14.8 per cent of the latter.

Neck Girth

The data appear in Table 18.

TABLE 18

Mean Neck Girth (in Centimeters) of Males With Various Diseases

(Age data and references same as in Table 9)

ORDER	GROUP	MEAN NECK GIRTH (*cm.*)	*N*
1	Gall bladder disease	39.12	16
2	**Cardiacs**	**37.21±.26**	**84**
3	**Non-cardiacs**	**36.20±.20**	**50**
4	Tuberculosis	36.18	75
5	Pernicious anemia	35.78	19
6	Nephritis and hypertension	35.72	15
7	Gastric and duodenal ulcer	34.91	30

Neck girth is, like all other girths except that of the head, considerably influenced by nutritional status, a degree of fleshing. The groups in Table 18 arrange themselves generally in consilience with this fact, but with exceptions so far as concerns Draper's tuberculous and pernicious anemia groups.

The difference between the highest and the lowest group mean Neck Girths of Table 18 is 12.1 per cent of the lowest mean, again reflecting the relatively high inter-group variation of this character.

Ear Dimensions

The data are given in Tables 19 and 20.

The groups arrange themselves in Table 19 in respect of mean Ear Length in nearly the order of their respective mean ages, a result in accord with the fact that the external ear increases in length with age practically throughout life. Ear Breadth does not clearly show this same relation to age, and is furthermore a dimension that, on account of

difficulty in precisely defining its boundaries, has not the same degree of precise comparability from measure to measure that many other anthropometric dimensions do.

The difference between highest and lowest group means in the ear dimensions of Table 19 and 20 are 9.1 per cent (for Ear Length) and 10.9 per cent (for Ear Breadth) of the respective lowest means.

TABLE 19

Mean Ear Length (in Centimeters) of Males With Various Diseases

(Age data and references same as in Table 9)

ORDER	GROUP	MEAN EAR LENGTH (*cm.*)	*N*
1	**Cardiacs**	**6.93±.04**	**87**
2	Gall bladder disease	6.82	17
3	**Non-cardiacs**	**6.77±.05**	**50**
4	Pernicious anemia	6.66	21
5	Gastric and duodenal ulcer	6.50	30
6	Nephritis and hypertension	6.36	18
7	Tuberculosis	6.35	75

TABLE 20

Mean Ear Breadth (in Centimeters) of Males With Various Diseases

(Age data and references same as in Table 9)

ORDER	GROUP	MEAN EAR BREADTH (*cm.*)	*N*
1	Gall bladder disease	3.67	17
2	Nephritis and hypertension	3.54	18
3	Tuberculosis	3.51	75
4	Gastric and duodenal ulcer	3.50	30
5	**Non-cardiacs**	**3.38±.04**	**50**
6	**Cardiacs**	**3.34±.03**	**87**
7	Pernicious anemia	3.31	21

BODY PROPORTIONS

In Table 21 are presented the biometric constants for a series of derivative variables computed from the absolute dimensions discussed in connection with Table 2. These derivative constants are anthropometric indices of the shape and proportions of the body. In each case the index (ratio or product) was separately calculated for each single individual in both cardiac and non-cardiac groups. Frequency distributions were then formed and the biometric constants of Table 21 computed in the usual way from these distributions, together with their probable errors.

From Table 21 the following results emerge:

1. All of the indices relating chest and/or trunk dimensions to stature (Chest Girth Index; Height Index; Trunk Length Index; Biacromial Breadth Index; and Biiliac Breadth Index) exhibit *larger* means in the cardiacs than in the non-cardiacs, by an amount which is statistically significant in the case of the Biiliac Breadth Index, and probably so in the case of the Chest Girth and Biacromial Breadth Indices.

2. The cardiacs are definitely more variable in respect of the Chest Girth Index than the non-cardiacs, and somewhat more so in respect of the Trunk Length Index.

3. The mean ratio of Biacromial Breadth to Trunk Length is larger in the cardiacs than in the non-cardiacs, but by an amount only 2.3 times the probable error of the difference.

4. The Diametrial Trunk Product, which is devised to give an indication of the total bulk or volume of the trunk, has a definitely higher mean value in the cardiacs than in the non-cardiacs, the difference being 5 times its probable error. It is also more variable, both absolutely and relatively, in the cardiacs.

5. The most interesting and significant chest index appears to us to be that which relates chest expansion to chest girth (expiration). It indicates the functional worth of the chest (breathing) mechanism. The data show that, on the average, in spite of the greater absolute dimensions of the chest in the cardiac, it is significantly less effective as a breathing mechanism, the mean Chest Expansion Index being larger in the non-cardiacs than in the cardiacs by 24 per cent, an amount 5 times the probable error of the difference. Sixty per cent of the non-cardiacs

TABLE 21

Anthropometric Indices for Cardiacs and Non-cardiacs

VARIABLE	*N*	MEAN	MEDIAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MINIMUM OBS.	MAXIMUM OBS.	RANGE
100 Chest girth (rest) / Stature								
Cardiacs	87	55.61±.41	55.06±.51	5.66±.29	10.18± .53	45.2	74.9	29.7
Non-cardiacs	50	53.50±.38	53.34±.48	3.99±.27	7.46± .51	43.9	63.6	19.7
100 Sitting height / Stature								
Cardiacs	87	52.01±.11	52.07±.14	1.51±.08	2.90± .15	48.5	55.9	7.4
Non-cardiacs	50	51.68±.16	51.64±.20	1.66±.11	3.21± .22	48.6	55.1	6.5
100 Trunk length / Stature								
Cardiacs	87	33.42±.12	33.67±.15	1.67±.09	5.00± .26	29.3	36.3	7.0
Non-cardiacs	47	32.97±.14	32.96±.17	1.40±.10	4.25± .30	30.2	36.3	6.1
100 Biacromial breadth / Stature								
Cardiacs	87	22.43±.13	22.69±.16	1.83±.09	8.16± .42	16.5	26.1	9.6
Non-cardiacs	50	21.60±.20	21.88±.25	2.09±.14	9.68± .66	16.6	24.9	8.3
100 Biiliac breadth / Stature								

$100 \times \frac{\text{Biiliac breadth}}{\text{Stature}}$									
Cardiacs	86	17.47±.08	17.36±.10	1.09±.06	6.24± .32	14.1	20.6	6.5
Non-cardiacs	49	16.77±.11	16.74±.14	1.13±.08	6.74± .46	13.7	19.7	6.0
$100 \times \frac{\text{Biacromial breadth}}{\text{Trunk length}}$									
Cardiacs	87	67.04±.44	67.20±.55	6.12±.31	9.13± .47	49.7	87.1	37.4
Non-cardiacs	47	65.16±.70	66.14±.88	7.14±.50	10.96± .77	48.4	78.4	30.0
$\frac{\text{Trunk length} \times \text{Chest depth} \times \text{Biacromial breadth}}{1000}$									
Cardiacs	87	46.01±.65	44.72±.81	8.96±.46	19.47±1.03	29.1	70.7	41.6
Non-cardiacs	47	41.55±.61	41.73±.77	6.25±.43	15.04±1.07	28.3	52.6	24.3
$100 \times \frac{\text{Chest girth (inspiration)}}{\text{Chest girth (rest)}}$									
Cardiacs	87	103.83±.12	103.63±.15	1.69±.09	1.63± .08	100.5	108.5	8.0
Non-cardiacs	50	104.86±.19	104.69±.23	1.95±.13	1.87± .13	101.5	112.2	10.7
$100 \times \frac{\text{Chest girth (expiration)}}{\text{Chest girth (rest)}}$									
Cardiacs	87	97.37±.10	97.45±.13	1.42±.07	1.46± .07	93.4	99.9	6.5
Non-cardiacs	50	96.78±.16	96.82±.20	1.71±.12	1.77± .12	92.4	99.5	7.1
$100 \times \frac{\text{Chest expansion (Insp. girth} - \text{Exp. girth)}}{\text{Chest girth (expiration)}}$									
Cardiacs	87	6.72±.16	6.59±.20	2.20±.11	32.74±1.84	1.5	15.9	14.4
Non-cardiacs	50	8.32±.28	8.33±.35	2.95±.20	35.46±2.68	3.0	17.4	14.4
Cephalic index									
Cardiacs	87	76.66±.31	76.77±.38	4.23±.22	5.52± .29	63.4	85.8	22.4
Non-cardiacs	50	77.90±.43	78.11±.54	4.54±.31	5.83± .40	62.2	84.6	22.4

have a Chest Expansion Index of 7.5 or greater, as against 33.3 per cent in the cardiacs.

There have been a number of studies on the variation of lung ventilation and vital capacity in individuals with dyspnoea. In none of these have the chest measurements been considered. Probably the most interesting investigation from our standpoint is that of Peabody and Wentworth (22) who confirmed the observation of Arnold (1) in 1855 that the vital capacity of the lungs is diminished in patients with heart disease. The above authors also found that this decrease is inversely related to the degree of dyspnoea. This work was continued by Peabody and Sturgis (21) who conclude in a later publication: "It is suggested that the two factors which account for the greater dyspnoea in the cardiac patients are the inadequate circulation, which results in a delayed elimination of carbon dioxide and the *tendency to shallow breathing* which necessitates a relatively large pulmonary ventilation." (Our italics). Later Engelhard considered that it would be of diagnostic importance to calculate the ratios:

$$\frac{\text{Maximum Ventilation}}{\text{Vital Capacity}} \text{ and } \frac{\text{Maximum Ventilation}}{\text{Respiration Rate}}$$

the first being found increased, the latter decreased in cardiacs. More recent studies by Harrison (15) and his associates have reached similar results.

6. The present group of cardiacs is, like the non-cardiacs, mesocephalic, but with a tendency to be more dolichocephalic than our non-cardiacs, by an amount that is just possibly statistically significant.

The relative (percentage) distribution of the two groups relative to cephalic index is of some interest. We have, on the standard classification (cf. Wilder, (34) p. 63):

Cephalic Index Limits		*Percentage Frequency in Cardiacs*	*Non-cardiacs*
Ultradolichocephalic	(61—65.99)	1.1	2.0
Hyperdolichocephalic	(66—70.99)	5.7	2.0
Dolichocephalic	(71—75.99)	36.8	30.0
Mesocephalic	(76—80.99)	41.4	38.0
Brachycephalic	(81—85.99)	14.9	28.0
Hyperbrachycephalic	(86—90.99)	0	0
Ultrabrachycephalic	(91—95.99)	0	0

Draper's (11) data give the following mean values for cephalic index, calculated by the present writers from the mean absolute skull dimensions given in his Table 105.

Gall bladder disease	80.9	(Mesocephalic)
Gastric and duodenal ulcer	79.3	(Mesocephalic)
Nephritis and hypertension	78.3	(Mesocephalic)
Pernicious anemia	82.5	(Brachycephalic)
Tuberculosis	78.3	(Mesocephalic)

With the exception of the pernicious anemia group it is evident that Draper's hospital samples, like ours, tend to be mesocephalic, considered as groups.

Hrdlička (17, p. 156) gives for his "Laboratory" and "Virginia" groups of Old Americans combined (594 males) a mean cephalic index of 78.2, and for his "Tennessee Highlanders" group (133 males) a mean of 77.5. These values are plainly quite close to our hospital samples.

7. Of the 11 indices here discussed, the Diametral Trunk Product is the most variable absolutely, if judged by the standard deviations and range, but this is a product and therefore cannot fairly be compared with the other indices that are quotients. The Chest Expansion Index is the most variable relatively, as judged by the coefficient of variation. The least variable indices in the series are those relating the Chest Girths to each other directly.

TABLE 22

Distribution of Cardiacs and Non-cardiacs According to Bodily Habitus

TYPE SCALE NUMBERS	TRUNK		LIMBS	
	Cardiacs	Non-cardiacs	Cardiacs	Non-cardiacs
0	1	..	2	1
1	1	..	4	5
2	3	2	5	5
3	3	4	18	6
4	6	5	14	11
5	16	8	15	6
6	25	20	12	12
7	7	4	8	2
8	8	1	5	0
9	10	3	3	2
10	4	3	0	..
11	1	..	0	..
12	2	..	1	..
Totals	87	50	87	50

SOMATOLOGICAL TYPES

While there exist no such things as sharply delimited "types" of bodily habitus, as has been pointed out by various authors (cf. 24 for discussion of the matter), nevertheless it is of interest to examine the arrangement of the present material relative to the standard somatological or so-called "constitutional" categories of "types."

The present material was typed by careful study of the nude patients at the time of examination and their photographs made in the manner described in (26). The judgments were recorded on our standard 13-point dual scale (26 and 24), for trunk and limbs separately. On these scales 0 represents the most extreme asthenic habitus, and 12 the most extreme pyknic habitus, while 6 denotes the perfect intermediate ("athletic" of Kretschmer) bodily habitus. The resulting distributions are shown in Table 22.

Inspection of Table 22 indicates at once that there are no very striking differences in these distributions as between cardiacs and non-cardiacs. The individuals of both series spread fairly well and about equally over the whole range of type scale numbers. If we calculate the mean type scale numbers for each of the four distributions the results are as follows:

Group		*Mean type scale number*
Cardiacs.	Trunk typing.....	6.80±.17
Non-cardiacs.	Trunk typing.....	6.28±.18
Cardiacs.	Limb typing.....	5.17±.17
Non-cardiacs.	Limb typing.....	4.72±.19

While the non-cardiacs evidently bulk a little more towards the asthenic end of the scale, the differences are too small to be statistically significant, having regard to errors of sampling.

In these two present groups, as we have found to be the case usually in our experience in somatological typing, the limbs of a given group of individuals tend to distribute themselves more towards the asthenic end of the scale than do the trunks of the same individuals, especially at ages such as those here dealt with. As judged by the mean type scale numbers in the present groups this tendency is great enough to be statistically significant. It is a numerical expression of the fact, familiar

to anthropologists and clinicians, that as a human being "fills out" with advancing age he (or she) tends to "fill" more in the trunk than in the limbs.

As a convenient numerical index of dysplasia we are accustomed in our constitutional work in this laboratory to use the differences (regardless of sign) between the type scale numbers for the trunk and the limbs in the same individual. The distributions of these differences in the present case are shown in Table 23.

TABLE 23

Degree of Dysplasia

(Difference between trunk and limb type scale numbers)

DEGREE OF DYSPLASIA	CARDIACS	NON-CARDIACS
0	17	11
1	27	14
2	19	15
3	17	7
4	4	2
5	3	1
Totals	87	50

Again there appears from Table 23 to be no great difference relative to degree of dysplasia as between cardiacs and non-cardiacs. The mean degree of dysplasia number for the cardiacs is 2.19±.09, while that for the non-cardiacs is 2.08±.11. Plainly the difference between the two groups cannot be regarded as significant. If we take degree of dysplasia numbers 0, 1, and 2 as indicative of substantial euplasia, and numbers 3, 4, and 5 as indicative of substantial dysplasia, it appears that among the cardiacs there are 72.4 per cent euplastics, and 27.6 dysplastics, as against 80.0 per cent euplastics and 20.0 per cent dysplastics among the non-cardiacs. There thus again appears to be a somewhat greater amount of dysplasia among the cardiacs than among the non-cardiacs

but the difference is not statistically significant. The percentages for the non-cardiacs agree very closely with Pearl's (24) 80.3 per cent euplastic and 19.7 per cent dysplastic, by the same criteria, among 290 white women.

Table 24 summarizes the data as to bodily habitus.

TABLE 24

Percentages of Somatological Types in Cardiacs and Non-cardiacs

BODILY HABITUS	TRUNK		LIMBS	
	Cardiacs	Non-cardiacs	Cardiacs	Non-cardiacs
Asthenic (Type scale Nos. 0-3)	9±3.0	12±4.6	33±5.0	34±6.8
Intermediate (Type scale Nos. 4-8)	71±4.0	76±6.0	62±5.0	62±6.9
Pyknic (Type scale Nos. 9-12)	20±4.0	12±4.6	5±2.0	4±2.8

Considering trunk and limbs separately it is plain that there is no significant difference between cardiacs and non-cardiacs in respect of distribution relative to somatological types. Relative to the trunk habitus alone there is a somewhat larger percentage of pyknics among the cardiacs than among the non-cardiacs. But the difference cannot be regarded as statistically significant, amounting only to 8±6.1 per cent. If we define for present purposes "pure" somatologically types as follows:

Pure asthenics		*Pure intermediates*		*Pure pyknics*	
Type scale numbers		*Type scale numbers*		*Type scale numbers*	
Trunk	Limbs	Trunk	Limbs	Trunk	Limbs
0	with 0, 1, or 2	4	with 4, 5, or 6	9	with 9, 10, or 11
1	with 0, 1, 2, or 3	5	with 4, 5, 6, or 7	10	with 9, 10, 11, or 12
2	with 0, 1, 2, or 3	6	with 4, 5, 6, 7, or 8	11	with 9, 10, 11, or 12
3	with 1, 2, or 3	7	with 5, 6, 7, or 8	12	with 10, 11, or 12
		8	with 6, 7, or 8		

TABLE 25

Numbers and Percentages of Pure Somatological Types in Cardiacs and Non-cardiacs

TYPES	CARDIACS		NON-CARDIACS	
	N	Percentage in whole group (87)	*N*	Percentage in whole group (50)
Pure asthenics	7	8.0	6	12.0
Pure intermediates	38	43.7	27	54.0
Pure pyknics	3	3.5	2	4.0
Totals	48	55.2	35	70.0

we then have the distributions of the numbers and percentages of these pure types in the cardiac and non-cardiac series given in Table 25.

Table 25 brings out the following points. Nearly 15 per cent more of the non-cardiacs than of the cardiacs fall into "pure" somatological types, as here defined. This expresses in another way the point already noted that the cardiacs display a somewhat greater tendency towards dysplasia than do the non-cardiacs in the present samples. The reason why the figures of Table 25 do not appear at first glance to be in agreement with those of Table 23 arises from the fact that the definitions of so-called "pure" types given above exclude transfers across the border limits of the three defined habitus types. An example will illustrate the meaning. An individual having trunk of scale number 4 and limbs of scale number 6, will by definition be classed as a "pure" intermediate, whereas an individual of trunk scale number 4 and limb scale number 2, though he shows the same degree of dysplasia as the former individual, will not, on our plan, be a "pure" somatological type at all.

When classified into defined "pure" types it is plain that there is no great difference between cardiacs and non-cardiacs in respect of this distribution relative to these types. Applying the χ^2 test to Table 25 we get a value of

$$\chi^2 = 0.1051,$$

TABLE 26

Bodily Dimensions of Asthenics (Trunk Type Scale Numbers 0-3)

CHARACTER	*N*	MEAN	MEDIAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MINIMUM OBS.	MAXIMUM OBS.	RANGE
Weight (kg.)								
Cardiacs	7	59.29±2.42	58.33±3.03	9.49±1.71	16.01±2.96	44.5	75.6	31.1
Non-cardiacs	6	58.33±4.15	63.33±5.20	15.08±2.94	25.85±5.36	33.8	75.0	41.2
Stature (cm.)								
Cardiacs	8	176.88±1.72	177.50±2.16	7.63±1.22	4.31±0.73	162.5	186.4	23.9
Non-cardiacs	6	180.35±1.72	180.00±2.16	6.24±1.21	3.46±0.67	173.6	187.4	13.8
Chest Girth (rest.) (cm.)								
Cardiacs	8	86.25±1.12	86.65±1.40	5.00±0.80	5.80±0.98	78.0	94.8	16.8
Non-cardiacs	6	88.34±1.61	87.50±2.02	5.86±1.14	6.63±1.30	82.0	97.0	15.0

TABLE 27

Bodily Dimensions of Intermediates (Trunk Type Scale Numbers 4-8)

CHARACTER	*N*	MEAN	MEDIAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MINIMUM OBS.	MAXIMUM OBS.	RANGE
Weight (kg.)								
Cardiacs	60	66.83±0.93	66.00±1.17	10.65±0.66	15.94±1.01	45.4	99.0	53.6
Non-cardiacs	37	64.19±0.99	64.17±1.24	8.96±0.70	13.96±1.12	38.0	88.0	50.0
Stature (cm.)								
Cardiacs	62	168.39±0.56	168.26±0.70	6.54±0.40	3.88±0.24	151.3	185.2	33.9
Non-cardiacs	38	170.13±0.92	171.10±1.15	8.37±0.65	4.92±0.38	154.3	188.0	33.7
Chest Girth (rest.) (cm.)								
Cardiacs	62	92.02±0.59	91.25±0.74	6.85±0.41	7.44±0.45	79.0	113.0	34.0
Non-cardiacs	38	89.48±0.52	89.71±0.65	4.73±0.37	5.29±0.41	74.0	104.0	30.0

TABLE 28

Bodily Dimensions of Pyknics (Trunk Type Scale Numbers 9-12)

CHARACTER	*N*	MEAN	MEDIAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MINIMUM OBS.	MAXIMUM OBS.	RANGE
Weight (kg.)								
Cardiacs	17	90.29±3.13	90.00±3.92	19.13±2.21	21.19±2.56	69.5	137.5	68.0
Non-cardiacs	6	74.83±2.08	73.33±2.61	7.56±1.47	10.10±1.99	63.4	82.5	19.1
Stature (cm.)								
Cardiacs	17	168.09±0.96	166.88±1.20	5.84±0.68	3.47±0.40	160.4	179.5	19.1
Non-cardiacs	6	162.50±1.74	160.00±2.18	6.33±1.23	3.90±0.76	157.7	170.0	12.3
Chest Girth (rest.) (cm.)								
Cardiacs	17	106.62±1.45	103.75±1.82	8.89±1.03	8.34±0.97	95.0	127.0	32.0
Non-cardiacs	6	99.17±1.14	100.00±1.43	4.15±0.81	4.18±0.82	92.0	101.0	9.0

whence quite plainly there is no significant difference in the distribution of the "pure" somatic types or between cardiacs and non-cardiacs.

It is desirable now to examine the material in another way. We need an answer to the following question: How do the cardiac asthenics differ quantitatively from the non-cardiac asthenics in respect of their principal bodily dimensions? And similarly for cardiac and non-cardiac intermediates, and cardiac and non-cardiac pyknics?

The data to answer these questions so far as concerns the three important dimensions Body Weight, Stature, and Chest Girth are given in Tables 26-28 inclusive, so far as concerns trunk type.

While the numbers involved are very small, except in the case of the intermediates, the trends of the figures in Tables 26-28 are of considerable interest. We note that:

1. In all three types, asthenic, intermediate, and pyknic, the mean Body Weight is greater in the cardiacs than in the non-cardiacs. That is to say, a cardiac pyknic, on the average, is heavier than a non-cardiac pyknic, and so similarly for asthenics and intermediates. This again emphasizes the association, to which we have repeatedly drawn attention in this paper, between extra body fat and cardiac disease in this material. The difference in body weight is statistically insignificant, having regard to its probable error, in asthenics and intermediates, but is significant ($Diff./P.E._{diff.} = 4.1$) in the pyknics. We suspect that the trend shown here would be confirmed if larger series were available, with consequently smaller probable errors.

2. Mean Body Weight increases from asthenics through intermediates to pyknics—an expected result—and by quite substantial amounts.

3. In Stature there is no significant or substantial difference between cardiacs and non-cardiacs in any of the three types.

4. Mean Stature decreases as we pass from asthenics to intermediates to pyknics. But again, because of the smallness of the numbers, the differences cannot all be regarded as statistically significant.

5. Mean Chest Girth is greater in the intermediate and pyknic cardiacs than in the non-cardiacs of corresponding bodily habitus types. In the asthenics the difference is the other way.

6. Mean Chest Girth increases from the asthenics, through the intermediates, to the pyknics.

Altogether the evidence from Tables 26-28, while unfortunately too meager to lead to definitive conclusions, suggests that in each bodily habitus type the cardiacs tend to be heavier and of greater girth than

the non-cardiacs of the same somatological types. This finding is in agreement with the other results brought out above, and again points to the over-fatness of the cardiac group.

EFFECT OF SELECTION OF MATERIAL FOR GREATER HOMOGENEITY IN AGE

In an earlier section of this paper it was pointed out that our total material classifiable into cardiac and non-cardiac groups fell, when so divided, into two lots rather considerably discrepant in their age distributions. Consequently for the sake of greater homogeneity in the compared groups we restricted both to persons aged between 40 and 69 years inclusive, with a consequent loss of 25 individuals from the cardiac group, and of 83 individuals from the non-cardiac group.

Now that we have analyzed the data from the reduced, but relatively age-homogeneous, groups it seems desirable to examine realistically the question as to whether we probably made any significant gain from an anthropometric point of view in throwing out such large proportions of the total material. It is, of course, well known that after age 20-25 years the dimensions of the body change but comparatively little with advancing age, except in the case of characters, particularly such as body girths, that are markedly influenced by nutritional status or particular specific diseases.

We have analyzed the total material with practically the same thoroughness that we have the shorter and more age-homogeneous series with which this paper has so far dealt. But here we have space to present only the data for the *means* of the complete cardiac and non-cardiac groups. These means are given in Table 29.

We have carefully compared the means of Table 29 with the corresponding ones of Table 2 with the following results:

1. From a qualitative point of view the sense of no result or conclusion reached in this paper from examination of the means of the smaller (selected) series would have been altered if we had used the larger (total) series. Quantitatively most of the results and conclusions reached from the study of the means would have been somewhat more firmly established, because of the smaller sampling errors involved, if we had used the larger series.

2. Of the 44 means compared pair by pair we find *no significant differences* between the means of the longer and shorter series in 37

TABLE 29

Mean Measurements of Cardiacs (112) and Non-cardiacs (133) in Total Sample Unselected for Age

CHARACTER	CARDIACS	NON-CARDIACS
Body weight (kg.)	69.63±0.98	64.30±0.63
Stature (cm.)	168.80±0.42	172.12±0.45
Height at ext. auditory meatus (cm.)	155.45±0.43	158.63±0.45
Height at suprasternal notch (cm.)	138.13±0.38	140.58±0.41
Height at lower costal margin (cm.)	108.98±0.33	110.61±0.41
Height—sitting (cm.)	87.72±0.22	88.98±0.24
Height—trunk (cm.)	56.28±0.19	56.50±0.20
Span (cm.)	175.34±0.48	179.10±0.55
Head length (cm.)	19.01±0.06	18.85±0.05
Head breadth (cm.)	14.54±0.05	14.19±0.06
Breadth—Biacromial (cm.)	37.45±0.20	37.06±0.19
Breadth—Biiliac (cm.)	29.18±0.13	27.83±0.12
Breadth—Greatest hip (cm.)	33.77±0.13	32.68±0.12
Chest Depth (cm.)	21.33±0.18	19.50±0.11
Girth—head (cm.)	56.52±0.11	56.19±0.11
Girth—neck (cm.)	37.01±0.22	36.10±0.13
Girth—chest: expiration (cm.)	90.62±0.57	86.11±0.37
Girth—chest: rest (cm.)	93.35±0.60	88.78±0.37
Girth—chest: inspiration (cm.)	97.17±0.57	93.67±0.37
Girth at umbilicus (cm.)	91.85±0.91	81.72±0.52
Ear length (cm.)	6.93±0.04	6.57±0.03
Ear breadth (cm.)	3.33±0.03	3.28±0.03

cases. All of the remaining 7 cases concern the *non-cardiacs*. In three of these 7 cases (Head Breadth, Chest Depth, and Girth at Umbilicus) the means for the smaller (selected) non-cardiac groups are *greater* than those for the larger (total) non-cardiac groups by statistically significant amounts (Diff./P.E. diff. 5.0, 5.7, and 5.2 respectively). In three other cases out of the 7 (Biiliac Breadth, Chest Girth—Expiration, and Ear Length) the means for the smaller (selected) non-cardiac groups are again *greater* than those for the larger (total) non-cardiac groups, by amounts probably statistically significant (Diff./P.E. diff. 3.3, 3.4, 3.3 respectively). Finally, in the case of Head Girth, the mean for the larger (total) non-cardiac group is greater than that for the smaller (selected) non-cardiac group, by an amount that might by some

be regarded as probably significant (Diff./P.E. diff. = 2.8) but in our opinion this would be a highly dubious judgment. Differences as great or greater than this may occur by chance alone once in 16 or 17 trials.

Summarizing, it appears to us that the only sensible conclusion to be drawn is that our selection of the material for age-homogeneity was, realistically viewed in the light of the results, rather pedantic, so far as concerns the material here discussed.

SUMMARY AND DISCUSSION OF RESULTS

In this paper we have compared anthropometrically and constitutionally two groups of living individuals. In one of these groups (called the cardiacs) each individual has some clinically recognizable heart disease. In the other group (called non-cardiacs) no individual has any clinically recognizable heart disease, or lesion of the circulatory system. In this non-cardiac group there was practically no nephritis or diabetes, but relatively more syphilis and malignancy, as a group, than in the cardiacs. All the individuals in both groups fall in age between the limits 40 and 69 years.

The two groups are *substantially identical* in respect of mean Stature, Span, Head Length, Head Breadth, Biacromial Breadth, Ear Length, Ear Breadth, Height at External Auditory Meatus, Height at Suprasternal Notch, Height at Lower Costal Margin, Sitting Height, and Trunk Length.

The cardiac group exhibits means *larger* than the non-cardiac group, by amounts certainly or very probably statistically significant having regard to the probable errors, in respect of the following dimensions: Body Weight, Biiliac Breadth, Greatest Hip Breadth, Chest Depth, Head Girth, Neck Girth, Chest Girth at Expiration, at Rest, and at Inspiration, and Girth at the Umbilicus.

The cardiacs tend to be *more variable* than the non-cardiacs both absolutely and relatively, in respect of those dimensions for which they have the larger means.

The Chest Expansion Index is significantly *smaller,* on the average, in the cardiacs than in the non-cardiacs. Also the cardiacs, as a group, tend somewhat more towards dolichocephaly than the non-cardiacs, though the means place both groups in the mesocephalic class in the standard system.

There is no substantial, or even statistically significant difference between cardiacs and non-cardiacs in respect of their distributions relative to the three standard somatological types, asthenic, intermediate, and pyknic.

Biometrical analysis of the total available material, ranging in age from 20 to 69 years, shows that none of the conclusions drawn from the means of the smaller groups selected for greater age-homogeneity would have been changed if we had used the total material.

The broad general result that emerges from this study appears to us to be that in a group of white males with definite heart disease of one sort or another we have a group characterized somatologically, on the average, primarily by greater body weight consequent chiefly upon greater body girths and breadths, particularly of the trunk and chest, as compared with a group of white males of substantially the same average stature in which there is no cardiac or circulatory disease. Accompanying this structural difference goes also a significant functional deficiency of the chest, as a breathing mechanism. All the evidence points to the conclusion that these characteristics of the cardiac group are not the consequence of true innate constitutional differences in the usual sense of the words, but are rather due to accumulation of body fat from relative over-eating and lack of physical exercise. This conclusion is supported by a considerable body of evidence set forth in detail in the text and tables. For example the distributions as to somatological types are substantially identical in the two groups. Furthermore Davenport and Love's data on young cardiacs (draft recruits) presented in Tables 4-8 show that at these ages there is no marked somatological differentiation of cardiacs from non-cardiacs. Again the individuals in our cardiac group belonging to each of the three somatological types, asthenic, intermediate and pyknic, tend to be heavier and of greater girth than the individuals *of the same type* who are non-cardiacs.

It must be clearly understood that we are not asserting that overfatness has been proved to be the primary, or even a significant, factor in the etiology of the heart disease of middle or later life. All we suggest is that the present data indicate a statistical association between the two phenomena, the full meaning and significance of which association must await further investigation.

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A STATISTICAL APPROACH TO THE PROBLEM OF TONE LOCALIZATION IN THE HUMAN COCHLEA*

BY ANTONIO CIOCCO

THIS paper presents the method used in determining by statistical analysis the existence and position in the human cochlea of areas which respond to the frequencies of 4096 d.v. (c^5) and 8192 d.v. (c^6).

That a satisfactory solution of this complex physiological problem can be arrived at by elementary statistical analysis is considered of interest. The method by which the available data have been reduced to terms suitable for statistical treatment is of fundamental importance and is here given in detail. Emphasis is also placed upon the conditions particular to the nature of this problem, knowledge of which is essential for evaluation of the findings.

The problem is: does there exist a definite area in the cochlea which responds to a given tone? If such an area exists, what is the relation between the severity of pathologic lesion and that of hearing impairment?

MATERIAL

The material is derived from the observations of Crowe, Guild and Polvogt[1] on temporal bone pathology in patients with impaired hearing for high tones. For this study I have utilized their charts of cochlear nerve pathology and the records of hearing acuity.

The nerve data for each cochlea are recorded in the form of a spiral graph, wherein the amount of nerve is represented by a solid band (Fig. 1). The proportion of the outlined zone which is filled shows the amount of nerve present at the several levels, relative to the normal.

* From the Otological Research Laboratory, The Johns Hopkins University.

[1] Crowe, S. J., S. R. Guild and L. M. Polvogt. Observations on the pathology of high tone deafness. Bull. Johns Hopkins Hosp., Vol. 54, pp. 315-380. May, 1934. The reader is referred to this work for details.

FIG. 1. AN EXAMPLE OF THE GRAPHIC NERVE RECORDS

The approximate equivalents of millimeters of actual cochlear length from the basal end are indicated. The black represents the amount of nerve present (i.e., the nerve supply for the organ of Corti at each level).

Individual variations in cochlear size have been compensated for by careful adjustment of all to a standard spiral graph; this permits comparisons between corresponding levels in different cochleae.

The hearing acuity has been measured with Western Electric Co. 1-A or 2-A audiometers. The threshold for each tone tested is expressed in decibels above a calculated normal[2] (Fig. 2). For most patients only octave interval tones were tested; this limits the study.

[2] The basis for this "normal" is described in Part III, Chapter II of H. Fletcher, Speech and Hearing. *New York*, 1929. D. van Nostrand Co.

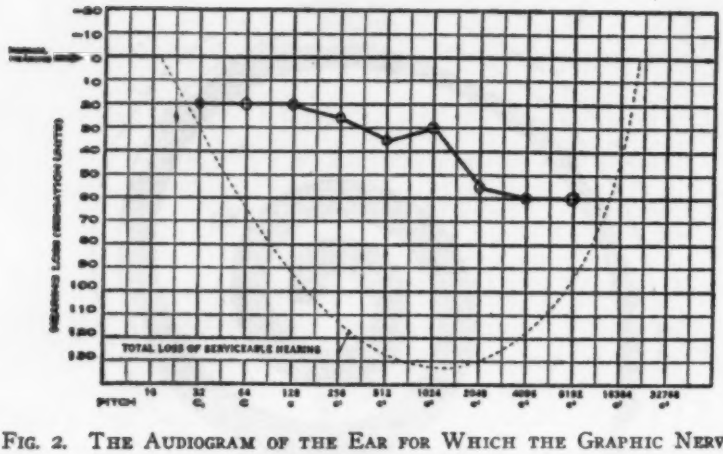

FIG. 2. THE AUDIOGRAM OF THE EAR FOR WHICH THE GRAPHIC NERVE RECORD IS SHOWN IN FIG. 1.

METHOD

The existence of a specific area directly related to the hearing of an individual tone must necessarily mean that with more nerve atrophy in that area a greater intensity of stimulus is needed for its perception. Therefore the hearing loss is considered as a variable dependent upon the nerve loss, within the limits of the area of response. Since these limits are the unknown factors, one must seek for areas in which there is correlation between hearing and pathology. It can be stated then: the condition sufficient to demonstrate the existence and position of an area directly related to the perception of an individual tone is that there be definite relation between increase in degree of nerve atrophy and increase in degree of hearing impairment.

It is quite impossible to expect that there be one and only one area in which there is definite interrelation between the hearing and the pathology. One reason is that sharply localized areas of nerve atrophy are seldom found. Most commonly the degree of atrophy is greatest at the basal end, as in the example shown. In only a few cases is atrophy found beyond the basal turn, which is about 17 mm. in length, as indicated by the broken line in figure 1. This limits the problem to a consideration of the basal turn. Changes in amount of atrophy may be gradual or abrupt and appear at any level in this turn.

The problem is thus reduced to a form suitable for statistical treatment. This is achieved by tabulating systematically for each tone the hearing loss in relation to the amount of nerve atrophy in successive areas of the individual cochleae. The frequency distributions in the series of tables thus obtained show whether or not there are areas with definite relation between the elements.

To individualize the areas every spiral graph has been divided into equal parts, each corresponding to an actual length of about ⅓ mm. of cochlear structure. Tables have been made for these small areas individually, and for the combinations of them taken in succession two by two, three by three, etc., up to 18 by 18. The combination of successive areas three by three gave the best evidence of relationship.

The degree of nerve atrophy has been grouped as follows: (1) normal to less than 25 per cent loss, (2) between 25 and 50 per cent loss, (3) loss of 50 to 100 per cent.

THE AREA OF RESPONSE TO 4096 D.V. (c^5)

Lack of space forbids the presentation of all of the tables constructed. Five are here reproduced. These are illustrative of the change in the frequency distributions for areas at different distances from the basal end of the cochlea.

In Table 1, part 1, for the area 3⅔ to 4⅔ mm. from the end, the mean value of hearing loss increases with the amount of nerve atrophy, but there is marked dispersion both in the sense of the columns and of the rows. Therefore, this cannot be the area sought. Variability increases progressively for the areas nearer the basal end (tables not reproduced) and decreases for those more distant.

At 7⅚ to 8⅚ mm. (Table 1, part 3), the dispersion for the rows is a minimum and there is a maximum of difference between the means of the hearing thresholds for the successive degrees of nerve atrophy. If one should find it advisable to calculate for all the tables a correlation ratio, at this level it would assume a maximum value.

Tabulations for areas farther from the basal end (Table 1, part 4) show a trend not so regular and with slightly greater variation. Yet further apicalwards, the tendency is for less and less differentiation of hearing in terms of pathology (Table 1, part 5, 13⅓ to 14⅓ mm.).

I have attempted by the selection of the tables reproduced to give the view that is had from all the tables together. Arranged in order of

TABLE 1

Hearing Thresholds for 4096 d.v. (c^5) and Nerve Pathology in Specific Areas

Distance of area from basal end, in mm.	PART 1 3⅗-4⅗			PART 2 6⅕-7⅕			PART 3 7⅘-8⅘			PART 4 10⅗-11⅗			PART 5 13⅕-14⅕		
Percentage nerve loss	—25	25-50	50+	—25	25-50	50+	—25	25-50	50+	—25	25-50	50+	—25	25-50	50+
Hearing threshold in decibels															
10	1	..	..	1	..	..	1	..	..	1	..	..	1	..	..
15	..	..	1	1	..	..	1	..	..	1	..	..	1	..	..
20	1	2	..	3	..	..	3	..	..	3	..	..	3	..	..
25	1	..	1	1	1	..	2	..	..	2	..	..	2	..	..
30	1	..	..	1	..	..	1	..	..	1	..	..	1	..	..
35	1	..	1	1	1	..	2	..	..	2	..	..	2	..	..
40	..	..	1	1	..	..	1	..	..	1	..	..	1	..	..
45	3	1	1	4	1	..	5	..	..	5	..	..	5	..	..
50	2	2	..	4	..	..	4	..	..	4	..	..	4	..	..
55	1	2	..	2	1	..	3	..	..	3	..	..	3	..	..
60	..	1	6	2	3	2	2	5	..	6	..	1	7	..	..
65+	1	..	16	1	2	14	..	2	15	5	10	2	13	4	..
Total	12	8	27	22	9	16	25	7	15	34	10	3	43	4	..
Mean	39.80	44.40	59.30	40.50	52.80	66.60	39.40	62.10	67.50	45.90	67.50	65.00	50.30	67.50	....
Standard deviation	15.56	14.67	14.13	15.92	13.91	2.48	14.61	3.39	....	16.72	....	3.62	17.12	....	....

the areas from the extreme lower basal upwards, they show irregularity of trend and maximum dispersion for the columns and rows at the basal end; both become less and reach a minimum in the table for the area 7⅝ to 8⅝ mm. Beyond this level, covariation decreases until a region is reached above which, no matter what the hearing is, there is little or no atrophy.

The area at 7⅝ to 8⅝ mm. from the basal end best satisfies the requirements underlying any correlation: viz., covariation, minimum dispersion. Especially is this so for the rows. In this problem the relation is one of cause and effect and not of generic "association." For this reason it is necessary that the dispersion of the rows be a minimum. Therefore, one cannot admit contradictions such as in parts 1 and 2 of Table 1, for which areas some individuals with better hearing than others have a greater amount of nerve atrophy. The correlation would be more significant if for each step in the raising of threshold there were a greater degree of nerve atrophy. However, the fact alone that the pathology considered is here limited to that of the nerve in the cochlea justifies the finding of a great variation in hearing loss associated with little or no pathology, so long as the previous condition holds good.

The tables for the areas surrounding that of 7⅝-8⅝ mm. show almost the same frequency distribution and but slightly more dispersion. This is most probably because the hearing for the frequencies immediately higher and lower than 4096 d.v. is also impaired to about the same degree. The available data do not permit me to measure and eliminate these influences.

The evidence indicates that in the human cochlea an area does exist which responds to stimulation by the frequency of 4096 d.v. (c^5), and that this area is located approximately 7⅝ to 8⅝ mm. from the basal end.

THE AREA OF RESPONSE TO 8192 D.V. (c^6)

For this tonal frequency, as for 4096 d.v., the combination of successive areas taken three by three gives the best evidence of relationship between hearing loss and pathology.

Five of the tabulations for this frequency are reproduced in Table 2. Analysis of the complete series of tables, using the criteria discussed above, shows that the area which best satisfies the requirements of this problem with respect to 8192 d.v. is that at 4 to 5 mm. from the basal end.

TABLE 2

Hearing Thresholds for 8192 d.v. (c^6) and Nerve Pathology in Specific Areas

Distance of area from basal end, in mm.	PART 1 ⅓-1⅓			PART 2 2⅔-3⅓			PART 3 4-5			PART 4 5⅓-6⅓			PART 5 11-12		
Percentage nerve loss	—25	25-50	50+	—25	25-50	50+	—25	25-50	50+	—25	25-50	50+	—25	25-50	50+
Hearing threshold in decibels															
20	..	..	1	..	1	..	1	..	..	1	..	..	1	..	..
25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
30	..	..	2	..	2	..	2	..	..	2	..	..	2	..	..
35	..	1	..	1	..	..	1	..	..	1	..	..	1	..	..
40	1	2	..	3	..	..	3	..	..	3	..	..	3	..	..
45	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
50	1	..	6	3	2	2	4	3	..	5	2	..	7	..	..
55+	..	..	37	..	3	34	..	8	29	4	10	23	23	11	3
Total	2	3	46	7	8	36	11	11	29	16	12	23	37	11	3
Mean	45.00	38.30	54.50	43.60	43.10	57.00	39.50	55.50	57.50	44.00	56.20	57.50	51.50	57.50	57.50
Standard deviation ..	5.00	2.30	7.87	5.80	14.12	1.72	9.64	3.34	....	11.20	2.80	....	9.63	....	....

RELATION BETWEEN DEGREE OF HEARING LOSS AND THAT OF NERVE ATROPHY

The second part of the problem, as stated in the introduction, is: what relation exists between the degree of hearing loss and that of nerve atrophy? This is answered in part 3 of each table, in which it appears that this relation is non-linear. If a regression curve could be calculated it would be extremely skew.

CONCLUSION

I have attempted to demonstrate by a detailed account of the method of approach that a problem in physiology, foreign to biometrics, can be satisfactorily solved by statistical analysis. That the reasoning underlying the method is correct is evidenced by the fact that the results are confirmatory of those obtained by Crowe et al.

In 1931[2] they concluded from two cases with localized hearing defects and localized cochlear lesions that the area most directly related to the perception of 4096 d.v. is about 8 or 9 mm. from the basal end, and for 8192 d.v. about 5 mm. Since that time they have found seven more such cases; these are included in their paper.[2]

My demonstration of the applicability of the statistical method to this unique problem indicates that the solution of many problems apparently non-statistical in nature may be achieved by suitable reduction of the data.

I wish to thank Dr. Raymond Pearl for the encouragement given me in the preparation of this paper.

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[2] Guild, S. R., S. J. Crowe, C. C. Bunch and L. M. Polvogt: Correlations of differences in the density of innervation, etc., *Acta Oto-Laryngologica*, 1931. Vol. 15, Fasc. 2-4.

RECENT LITERATURE

USEFUL IN THE STUDY OF HUMAN BIOLOGY

In this department will be noticed the books and reprints which are currently received at the Editorial Office. Publications intended for notice here should be addressed to Dr. Raymond Pearl, Department of Biology, School of Hygiene and Public Health, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

I. EVOLUTION AND GENETICS

1. *Evolution—General Principles*

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